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**Application of Probability Concepts to Management Decisions**

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# Control Charts *for Log-Normal Universes*

ENOCH B. FERRELL

*Bell Telephone Laboratories, Inc., Murray Hill, N. J.*

A great many processes produce results which form a distribution that is fairly near to Normal or Gaussian. But this in general tends to be true only if the variations in the results arise from many causes that are independent and that are additive.

One of the common non-Normal distributions is the Log-Normal. A Log-Normal distribution is one in which the logarithms of the numbers form a Normal distribution. This can result from a set of causes for variation that, though still independent, are multiplicative rather than additive. Causes that would affect the numbers in a multiplicative manner affect their logarithms in an additive manner.

An example is the amplification in a long telephone circuit that contains many repeaters or amplifiers. The overall amplification is the product of the amplifications of the individual repeaters. As these vary, because of differences in components or supply voltages, the overall amplifications of such systems tend to form Log-Normal distributions. Telephone engineers express the amplification in logarithmic units, decibels, and call it gain. Combinations of gains then become simple sums, and distributions of gains tend to approach Normality.

In some cases it is not convenient to make measurements directly in logarithmic units, and it becomes desirable to make a brute-force logarithmic transformation or to achieve its effects by some other methods. Fortunately there are other methods—quite simple ones.

For plotting cumulative probability or cumulative frequency of Log-Normal distributions we have "logarithmic probability paper." The frequency scale on this is the same as on arithmetic probability paper, but the scale for the chance variable is a logarithmic scale. A Log-Normal distribution plotted on this paper appears as a straight line.

***Abstract***

A method is suggested for computing and plotting control charts for samples from a badly skewed universe which can be approximated by a Log-Normal distribution. Suitable direct computation is proposed which can be done on the slide rule and which is equivalent to transformation into logarithms, analysis, and transformation back to the original scale. The geometric range, $\rho = \text{Max}/\text{Min}$, is used in place of the range. The geometric midrange, $\eta = \sqrt{\text{Max} \times \text{Min}}$, is used in place of the mean. Corresponding changes in computation of limits are described. This method gives an analysis which accepts the skewness of the universe and permits a search for other significant causes for variation.

Simple histograms of Log-Normal distributions can, of course, be plotted on semi-log paper. We use ratios instead of differences to define the cell boundaries and plot these cell boundaries on the logarithmic scale. We plot the probabilities on the linear scale. This gives us the symmetric bell shape of the Normal curve.

On the logarithmic scale the Log-Normal universe is, of course, symmetric about its mean. Hence, its mean is also its median. Now the antilogarithm of the mean of a set of logarithms is the geometric mean of the corresponding numbers. In fact, we usually compute the geometric mean by converting to logarithms, averaging, and converting back to numbers.

Since the logarithm of a larger number is always larger than the logarithm of a smaller number, the median of a set of numbers is the antilogarithm of the median of their logarithms. Hence, for a Log-Normal universe, or any universe whose logarithmic transform is symmetric, the median and the geometric mean are the same.

It appears, therefore, that for a Log-Normal universe we would use the geometric mean and/or the median wherever for a Normal universe we would use the arithmetic mean and/or the median.

If we generalize these ideas, we are led to treat a Log-Normal universe just as we treat a Normal universe with these three simple modifications of our procedures: Where we would normally use sums we will now use products; where we would normally use differences we will now use ratios; where we would normally multiply by a factor we will now raise to a power. We have already pointed out that for identifying the median, we need not change at all from our usual practices. The same is true for the extremes and other order statistics. The computation of the statistics that correspond to range and midrange now become quite simple.

The arithmetic range of a subgroup is the difference between the largest and smallest numbers in the subgroup. Suppose we convert to logarithms and then compute the range of the logarithms. This is the difference between the logarithms of the extremes. If we convert this logarithmic range back to numbers, we have the ratio of the extremes, rather than their difference. That is, the ratio of the extremes is the antilogarithm of the range of the logarithms. We might call this the geometric range. We will indicate it by a small Greek $\rho$, to distinguish it from the arithmetic range, R. It is easy to compute on the simple slide rule. If we compute ratios of extremes we have, in effect, transformed to logarithms, done our work, and then transformed back to the original scale.

Similarly, the arithmetic midrange is half the sum of the largest and smallest members of the subgroup. It is a measure of central value. If we convert to logarithms

and then compute the midrange of the logarithms, we have the average of the extremes of the logarithms. If we convert this logarithmic midrange back to simple numbers, we have the geometric mean of the extremes. That is, the geometric mean of the extremes is the antilogarithm of the midrange of the logarithms. We will call this the geometric midrange, and will indicate it by a capital script $\mathfrak{M}$ to distinguish it from the arithmetic midrange, M. It is easy to compute on the slide rule since it is merely the square-root of the product of the extremes. We have again, in effect, transformed to logarithms, done our work, and transformed back to the original scale.

In setting limits or tolerances in connection with a symmetric or near-Normal universe, we speak of "the arithmetic mean plus or minus some difference." Correspondingly, for the Log-Normal universe we should speak of "the geometric mean times or divided by some ratio." Now the "difference" in the arithmetic case is usually expressed in terms of the standard deviation, $\sigma$. In the Log-Normal case we need to express the "ratio" in terms of something analogous to $\sigma$. We might appropriately call this the geometric dispersion, g. We would define it as the antilogarithm of the standard deviation of the logarithms. Then corresponding to the expression "mean plus or minus $3\sigma$",

$$\bar{x} \pm 3\sigma,$$

we would have the expression, "median times or divided by $g^3$",

$$\tilde{x}g^{\pm 3}.$$

Here we have used the median in place of the geometric mean because it is simpler to compute, and because we expect them to be the same. Within the limits $\tilde{x}g^{\pm 3}$ we will expect to find about 99.7 percent of the universe.

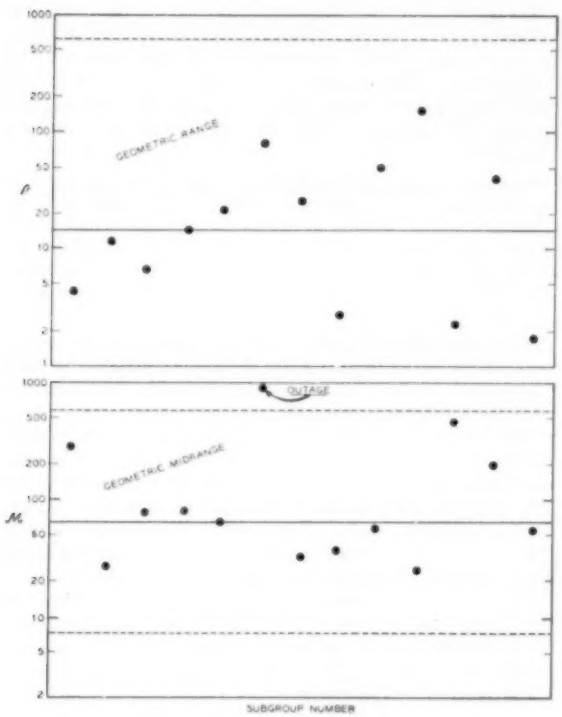


**Figure 1—Control Chart for Transistor Current Tested as a Log-Normal Distribution**

**TABLE I—Control Charts**

Variate: x. Sample size: n. Mean: $\bar{x}$.
Median: $\tilde{x}$. Standard deviation: $\sigma$.
Parent parameter indicated by prime.

*Samples From Normal Universe*

Range: $R = \text{Max} - \text{Min}$
Midrange: $M = (\text{Max} + \text{Min})/2$.
Estimates of parent parameters:

$$\sigma' = \bar{R}/d_4.$$
$$\bar{x}' = \bar{M}.$$

3-sigma limits on sample statistics:

$$\text{Lim } R = D_3\bar{R} \text{ and } D_4\bar{R}.$$
$$\text{Lim } M = \bar{M} \pm A_4\bar{R}.$$

*Samples From Log-Normal Universe*

Geometric Range: $\rho = \text{Max}/\text{Min}$
Geometric Midrange: $\mathfrak{M} = \sqrt{\text{Max} \times \text{Min}}$
Geometric Standard Deviation:

$$g = \text{antilog } \sigma(\log x).$$

Estimates of parent parameters:

$$g' = \bar{\rho}^{1/d_4}.$$
$$\tilde{x}' = \tilde{\mathfrak{M}}.$$

3-sigma limits on sample statistics:

$$\text{Lim } \rho = \bar{\rho}^{D_3} \text{ and } \bar{\rho}^{D_4}$$
$$\text{Lim } \mathfrak{M} = \tilde{\mathfrak{M}} \times \bar{\rho}^{\pm A_4}.$$

FACTORS FOR CONTROL CHARTS

| n | $A_4$ | $d_4$ | $D_3$ | $D_4$ |
|---|---|---|---|---|
| 2 | 2.224 | 0.954 | 0 | 3.865 |
| 3 | 1.137 | 1.588 | 0 | 2.745 |
| 4 | 0.828 | 1.978 | 0 | 2.375 |
| 5 | 0.679 | 2.257 | 0 | 2.179 |
| 6 | 0.590 | 2.472 | 0 | 2.055 |
| 7 | 0.530 | 2.645 | 0.078 | 1.967 |
| 8 | 0.486 | 2.791 | 0.139 | 1.901 |
| 9 | 0.453 | 2.916 | 0.187 | 1.850 |
| 10 | 0.427 | 3.024 | 0.227 | 1.809 |

Within the limits $\tilde{x}g^{\pm 1}$ we would expect to find about 68 percent of the universe.

The straightforward computation of g would be rather cumbersome. But we usually estimate $\sigma$ by computing the average of the ranges of several small samples and then dividing by the factor $d_2$,

$$\sigma' = \bar{R}/d_2.$$

Alternatively, we might compute the median of the ranges and divide by $d_4$. Thus $d_4$, being slightly different from $d_2$, takes account of the slight difference between the median range and the mean range.

For the Log-Normal case we would compute the median of the geometric ranges and then extract the $d_4$-th root.

$$g' = \sqrt[d_4]{\tilde{\rho}}$$

In a previous article*, we proposed to construct control charts for variables by the use of the three statis-

*"Control Charts Using Midranges and Medians," *Industrial Quality Control*, Vol. IX, No. 5, Mar. 1953, p. 30.

tics: range, midrange, and median. The corresponding statistics for the Log-Normal universe are ratio of the extremes, geometric mean of the extremes, and median. They are easily computed by the methods suggested here.

We have now gotten to a place where we can use our usual procedures in making a control chart analysis when the underlying universe is so badly skewed that it appears to be better approximated by the Log-Normal distribution than by the Normal. We first divide the data as usual into small rational subgroups. We compute and plot, preferably on semi-log paper, the geometric ranges, $\rho$, of these subgroups. We locate a central value of these geometric ranges at their median, $\tilde{\rho}$. We locate an upper "3-sigma" limit at $\rho^{D_6}$, where $D_6$ is a factor from Table I. The lower limit for the more usual subgroup sizes, corresponding to $\overline{RD}_5 = 0$, is $\tilde{\rho}^0 = 1$.

We also compute and plot the geometric midranges, $\mathfrak{m}_l$, of the subgroups. Again, it is preferable to plot these on semi-log paper. We locate a central value at the median of these geometric midranges, $\tilde{\mathfrak{m}}_l$. We locate "3-sigma" limits at

$$\tilde{\mathfrak{m}}_l \rho^{\pm A_4}$$

where $A_4$ is a factor from Table I.

When we use the techniques outlined here, the factors $A_4$, $d_4$, $D_5$, $D_6$ are the same for the Log-Normal universe as for the Normal universe. The computation of $\rho$ and $\mathfrak{m}_l$ is easily done on the simple slide rule with all the precision usually needed.

### *1959 Cleveland Convention Host Committee Announced*

Active convention planning is usually initiated at local level some two years in advance. During the past year the Host Committee for the Cleveland Convention in 1959 has been hard at work but now that the 1958 Convention is history the group will move into the final convention planning stages. Members of this Host Committee are:

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The General Convention Committee will work closely with the above group in all phases of design, planning and execution of the Convention.

**TABLE II—Transistor Current**

| Unit No. | I | $\rho_4$ | $\mathfrak{m}_{l_4}$ | Unit No. | I | $\rho_4$ | $\mathfrak{m}_{l_4}$ |
|---|---|---|---|---|---|---|---|
| 2 | 600 | | | 50 | 400 | | |
| 3 | 500 | | | 51 | 500 | | |
| 7 | 140 | | | 52 | 18 | | |
| 9 | 150 | 4.29 | 290. | 53 | 8 | 50. | 56.5 |
| 10 | 8 | | | 54 | 2 | | |
| 13 | 22 | | | 58 | 7 | | |
| 14 | 60 | | | 59 | 300 | | |
| 15 | 90 | 11.25 | 27.8 | 60 | 26 | 150. | 24.5 |
| 16 | 120 | | | 61 | 500 | | |
| 22 | 60 | | | 62 | 700 | | |
| 24 | 30 | | | 63 | 400 | | |
| 25 | 200 | 6.67 | 77.5 | 65 | 300 | 2.33 | 458. |
| 26 | 300 | | | 66 | 700 | | |
| 27 | 21 | | | 67 | 30 | | |
| 28 | 40 | | | 69 | 1200 | 40. | 190. |
| 29 | 50 | 14.28 | 79.4 | | | | |
| 31 | 14 | | | 71 | 40 | | |
| 32 | 300 | | | 74 | 50 | | |
| 33 | 130 | | | 76 | 70 | 1.75 | 52.9 |
| 34 | 100 | 21.43 | 64.9 | | | | |
| 36 | 100 | | | | | | |
| 37 | 300 | | | | | | |
| 38 | 1700 | | | | | | |
| 39 | 8000 | 80.00 | 894. | Median | | 14.3 | 64.9 |
| 40 | 160 | | | | | | |
| 43 | 100 | | | Lower Limit | | 1. | 7.15 |
| 44 | 60 | | | | | | |
| 45 | 6 | 25.7 | 31.6 | Upper Limit | | 607. | 589. |
| 46 | 50 | | | | | | |
| 47 | 22 | | | | | | |
| 48 | 40 | | | $g'$ | | 3.78 | |
| 49 | 60 | 2.73 | 36.3 | | | | |

Computation of the control limits now involves raising to powers but we can do this quite easily on the log-log slide rule. We can do it with all the precision usually needed by using the L-scale on the simple slide rule.

Consider, as an example, the data given in Table II. Here we have a particular current I for a certain set of transistors, measured under certain conditions.

In an earlier report this same data was plotted on Log-Normal paper and estimates of the universe parameters were made*. Table III compares the results.

As usual, the control chart analysis gives a smaller estimate of dispersion. The lumped data gives a summary of the actual performance at the time of the observation. The control chart tends to indicate the capability of the process. The outage in geometric midrange, 894, indicates that the performance could be improved.

**TABLE III—Lumped Summary vs Control Chart Analysis**

| | $\tilde{I}$ | $g$ | $\tilde{I}g^{\pm 3}$ |
|---|---|---|---|
| From Log-Normal Paper | 95 | 5.3 | 0.63 and 14200 |
| From Control Chart | 65 | 3.8 | 1.2 and 3500 |

The conventional arithmetic summary of the same data gives: $\bar{x} = 376$, $\sigma = 1158$, $\bar{x} \pm 3\sigma = -3098$ and 3850. This gives no very useful picture either of the distribution or of the process capability.

Let us review. We have started with the control chart, which is our simplest and fastest method of analyzing data. It is quite tolerant of departures from the Normal distribution on which it is based. Sometimes, however, we get data which is so badly skewed that the skewness itself produces outages and indicates the presence of assignable cause for variation.

With the tools described here, we can live with this skewness and go on with our control chart analysis. This permits us to accept the skewness as a natural property of the universe and continue our search for disturbances and intrusions.

*"Plotting Experimental Data on Normal or Log-Normal Probability Paper," *Industrial Quality Control*, Vol. XV, No. 1, July 1958, p. 12.

# Statistical Aids to Decision Making

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### *Introduction*

This article describes a direct application of probability concepts to management decisions. The basic principles used are similar to those applied in statistical quality control and design of experiment at operating and technical levels of business. A general pattern of analyzing problems, described popularly as *Design for Decision*[1], has been applied to real examples of decision making.

The aim is to combine careful estimates of costs and of returns with equally carefully estimated probabilities of the occurrence of various outcomes of alternative courses of action. When costs, returns and probabilities are combined, the value or desirability of the alternatives are expressed in quantitative terms. A comparison of the desirabilities of the several possible courses of action enables the manager to choose the most favorable one.

### *An Example of Design for Decision*

For example, design for decision may be applied to the consideration of a proffered Government contract. The alternative courses of action are to accept or to reject the contract. The outcomes of either acceptance or rejection may be success for the company in achieving the objectives of the contract, success for a competitor, or failure for the company. In order to come to the most economic decision, it is necessary to assign a probability of occurrence figure to each outcome and to determine, in dollars, the cost and return expected of each outcome. When these figures have been combined to give dollar values, a decision may be reached on the basis of maximizing the company's gain.

Reference to Table I will make it possible to describe the detailed steps by which the decision was reached to accept a contract for the development of metallic-fibre reinforced ceramics. The construction of the table follows, row by row, the steps in analyzing the problem.

The first step is to decide what alternatives are open to the company. After deciding that the only alternatives open are acceptance or rejection of the proposal, the conceivable outcomes have to be listed. The relationships of the outcomes determines the way that probabilities are assigned. A successful outcome means establishment of a market for metallic-fibre reinforced ceramics. This market is presumed to be zero right now and would continue to be zero until research has shown that the material can be produced commercially to compete with other materials that it might replace.

In this instance, company success and company failure are conditional. Either one or the other outcome must occur and the sum of the probabilities must be 1.0. It is considered, however, that the probability of a competitor's success is independent of the company's success; that is, the sum of all three probabilities under a given alternative will be greater than 1.0. It is possible to conceive of a situation in which the probabilities of all three of these outcomes would be conditional. For instance if it is likely that the second comer will abandon the field to the first comer. Another distinction to be made here is whether success means simply coming up with a satisfactory product or whether it means following through to a commanding position in the market. It should be pointed out in connection with the outcomes of rejection that the company planned to do the work anyway, even without contract support.

The assignment of probability values requires considerable experience and background. Although it is not usually necessary to estimate these precisely, it is quite important that the relative magnitude of the assigned probabilities be correct. The more information the administrator has about the technical aspects of the project, about the capacities and limitations of his company and its competitors, and about the field of work in general, the better the assignment of probabilities will be. What this means is that the decision can be no better than the information and skill that goes into making it. The design merely insures that all the available skill and information are used. It permits more clear-cut separation of many possible outcomes. It must be remembered the design is for the use of the administrator and does not relieve him to delegate decision to inferiors in knowledge and judgment. The design is a tool by which a skillful administrator marshals and surveys his facts.

**TABLE I—Decision Design—Metallic-fibre Reinforced Ceramics Project**

| Alternatives | Accept | | | Reject | | |
|---|---|---|---|---|---|---|
| Outcomes | Company Success | Competitor's Success | Company Failure | Company Success | Competitor's Success | Company Failure |
| Probability of Outcome, p | 0.6 | 0.5 | 0.4 | 0.4 | 0.6 | 0.6 |
| Return (in thousands of dollars) | $P+Y_1+Z=130$ | $P-Y_2=-20$ | $P=5$ | $Y_1-X=-50$ | $-Y_2-X-Z=-200$ | $-X=-100$ |
| Value or Desirability (p × Return) | +78 | −10 | +2 | −20 | −120 | −60 |

Where P = Profit on Contract = $5,000
$Y_1$ = Value of Commercial Market = $50,000
$Y_2$ = Value of Loss of Competitive Position = $25,000
Z = Value of Government Production Contract = $75,000
X = Cost of Research = $100,000

In the example, the probability of company success upon acceptance of the contract is modestly set at 0.6 and it follows that the probability of company failure must be 0.4. The competitor, who is a smart fellow, too, but will not have the advantage of government sponsorship, is assigned a slightly smaller probability of success, 0.5. Upon rejection, the company's outlook would be more pessimistic, due to inability to assign as much effort to the project, and a low probability of 0.4 is assigned. Consequently, the probability of company failure is 0.6 under this alternative. The competitor, however, with government support, is assumed to have the same advantage the company would have had, and is assigned a probability of 0.6 of success.

It is now necessary to arrive at some dollar figures for costs and returns. The profit from the project will be small. The value of the commercial market, considered for some relatively short payoff period, say three years, is about ten times as large as the profit. The loss of competitive position if a competitor also succeeds in developing the product is worth about half the total commercial value. The value of having the inside track on government production contracts is 50 percent greater than that of the commercial market (also on a short time scale). However, the cost of the research is large, of the order of 20 times the profit.

If the project is accepted and the company succeeds, the return will be the profit ($5,000), plus the value of the commercial market ($50,000), plus the value of government production contracts ($75,000), or $130,000. If a competitor succeeds, the return to the company will be the profit ($5,000), minus the value of the loss in competitive position (−$25,000), or −$20,000. If the company fails it will have only the profit from the contract ($5,000).

For the alternative of rejection, if the company succeeds, it will have the commercial market ($50,000), minus the cost of the research (−$100,000), or −$50,000. If a competitor succeeds, the return will be zero, minus the value of the lost market (−$25,000), minus the cost of research (−$100,000), minus the value of the government contract (−$75,000), or −$200,000. Finally, if the company fails, the return will be zero, minus the cost of the research, or −$100,000.

When these returns are multiplied by the appropriate probabilities, the value or desirability of each outcome is known. The most desirable outcome is the one with the largest plus value. Accordingly, analysis of this design has indicated that the company should accept the proposal.

**TABLE II—Steps in Decision Making**

1. List the possible alternative decisions.
2. List the possible outcomes of these decisions.
3. Choose a decision rule, focusing attention on the short or the long run, on loss-control or maximizing expected gain, depending on the business climate.
4. Rank or assign probabilities to the outcomes.
5. Estimate costs and returns and either rank or assign dollar values to each.
6. Evaluate each outcome using the chosen decision rule.
7. Test the value or desirability against some policy standard.

The above example has shown the steps followed in arriving at a decision, but much still remains to be said about the underlying concepts and the decision rules that may be followed. Before going further into these matters, however, the steps in the decision-making process will be summarized. This has been done in Table II.

The d e c i s i o n to accept the proffered Government contract was reached by applying a simple decision rule: the outcome was selected which had the largest plus value. This is but one of a number of rules suggested in the literature for application under differing circumstances.

### *A Decision Regarding Capital Expenditure*

The operation of some of these rules may be illustrated by applying them to a decision to approve or disapprove a request for a capital expenditure for purchase and installation of a stone saw for cutting ball wheels. This equipment was to be used for cutting sections out of ball wheels to meet customer specifications. The wheel finishing department had no available machinery to perform this operation. Part of the work was being done in the Abrasive Engineering Laboratory and part in the Machine Shop. It was claimed that the installation would reduce manufacturing c o s t, relieve the Abrasive Engineering Laboratory and the Machine Shop of production operations, and substantially improve delivery schedules through reduced transportation and handling time.

The rules will be applied successively to this problem and Table III will be built up a step at a time.

The alternative outcomes of approval of the request are: obtaining the advantages claimed, obtaining some advantages (but less than claimed) and failing to obtain any advantages. Careful consideration of the request and its accompanying letter of justification led to arranging the outcomes thus, in descending order of probability of occurrence. This arrangement is not inconsistent with a rather conservative appraisal of the request, since anything greater than a 50-50 chance for the first outcome should result in the above order. The outcomes of disapproval, in descending order, are: failing to obtain the advantages claimed, incurring further losses, and losing the business altogether. The possibility of further losses and even, eventually, of losing the business are inherent in the situation. However, they are remote as long as the b u s i n e s s is vigorously handled. By far the most probable outcome of disapproval is maintaining the status quo. For the time being, we need go no further in constructing Table IIIa.

### *Application of Various Decision Rules*

One of the simplest rules calls for choosing the alternative for which the return of the most probable outcome is largest. This does not require numerical evaluation of probabilities nor of returns. It requires only the ranking of the returns under the most probable outcomes for each alternative. It emphasizes the probabilities and is often used when one outcome has a very high probability. If the request is approved, the most probable outcome is that the advantages claimed will be obtained: if disapproved, that the advantages will not be obtained. Obviously, there is no need to refer to the dollar returns in the table because the former outcome will have the larger return except in the unlikely situation that the long term return is no larger than the cost. Therefore, the decision would be made to approve the request. Any desired policy limitation may be applied to qualify this decision, such as the very reasonable one that the return per annum shall not be less than 25 percent of the cost. On this basis, this decision is borderline, since the return claimed per annum (1/15 of $22,350) is only 22.7 percent of the cost ($6,570).

It is common practice to make decisions on the basis of present value which takes into account interest

factors. The effect of interest rates is implicit if not explicit in the use of average annual returns in this example. Computation of savings has taken into account cost of money for new capital expenditures. In a more general way, the application of a policy limitation to the number of years allowed for a pay-off reflects the degree of concern for variations in the economic climate.

Further discussion of the dollar returns used in the example will follow later.

A second rule calls for choosing the alternative which *could* lead to the largest return. This is a very optimistic rule. It focuses on the returns. It does not require evaluation of probabilities. Here we could again make our selection without referring to the numerical size of the returns although it is helpful to have them because of the policy qualification applying. It is enough to know which is the largest. The decision is the same as under the first rule because the largest net return ($15,780) is expected for the outcome of obtaining the advantages claimed upon approval of the request.

Under a third rule we would consider the least favorable return under each alternative and choose the alternative most favorable of the two. This is a very pessimistic rule. It emphasizes security. It applies what is known as a "loss-control criterion." It does not require evaluation of probabilities. This rule calls for comparing the return if approval fails to result in obtaining any advantages with the return if disapproval results in loss of the business. It does not require dollar figures to conclude that under this rule, the request should be approved. Note that this minimizes the loss (−$6,570 compared to −$67,500) if the worst should occur under either alternative. (Availability of the dollar return figures permits realistic appraisal of the worst eventualities.) This rule avoids application of limiting policy and is a panic solution.

To apply a fourth rule, it is necessary to complete Table III. This rule uses both probabilities and returns. It is applicable whether the probabilities are independent or contingent. It is the rule applied to the earlier example.

In Table IIIb contingent probability values have been assigned to the outcome under each alternative. Trust in the validity of the estimates of cost and return is only moderate, so that an even chance of obtaining the advantages claimed is expected. There is almost as high a probability that some advantage will be obtained though not as much as claimed, so a probability of 0.4 is assigned. The probability of failing to obtain any advantages if the proposal is approved is 0.1, by difference. If the proposal is disapproved, the probability of obtaining none of the claimed advantages is quite high, so 0.6 is assigned. Similarly, there is a pretty good chance, 0.3, that some further loss will be incurred and a small though real probability, 0.1, (obtained by difference) that the business will be lost altogether.

The cost is based on a proposal from a manufacturer of stone and marble cutting machinery and a Works Engineering estimate of installation labor and materials. The Industrial Engineering Department estimated that installation of this unit would reduce direct operating costs by 50 percent. On the basis of this and a 15 year depreciation period, the annual savings were calculated to be $1,490. Over the 15 year period, therefore, the return will be 15 × $1,490, or $22,350. The actual return, could, of course, be larger or it could be zero. It is likely that the actual return might be about half the amount claimed or $11,175, and this amount is assigned to the second outcome. The return on the third outcome is zero.

If the proposal is rejected, there will be no return. It is quite likely that due to poor service further losses would be incurred, say to the extent of one-tenth of the orders and 100 percent increase in service costs. Assuming an average value of $150.00 per wheel, a demand of 300 wheels per annum, and operating income of 15 percent of sales, the value of the business is $6,750 per annum. Ten percent of this (−$675), plus the additional service cost (−$150), times 15 equals −$12,375, which is the loss entered in Table IIIb. It is assumed that the business might be lost, not at once, but after five years, so that the loss given in the table for this outcome is −$6,750 times (15 −5), or −$67,500.

In applying the fourth rule, the net returns are multiplied by the probabilities to give the last line in Table IIIb, the value or desirability. The largest value is $7,890, which leads us to the same decision as all the preceding rules. We would again, as a final step, apply the policy requirement concerning ratio of the first year's return to cost.

Rule number five requires the calculation of the mathematical expectations of the two alternatives. This rule uses both probabilities and returns. It applies when probabilities are contingent. It focuses on what happens in the long run. For the alternative of approval, this is:

$$\begin{aligned} E_A &= (0.5 \times \$22{,}350) \\ &\quad + (0.4 \times \$11{,}175) \\ &\quad + 0 - \$6{,}570) \\ &= \$11{,}175 + \$4{,}470 - \$6{,}570 \\ &= \$\ 9{,}075 \end{aligned}$$

For the alternative of disapproval, this is:

$$\begin{aligned} E_D &= 0 + (0.3 \times -\$12{,}375) \\ &\quad + (0.1 \times -\$67{,}500) \\ &= -\$\ 3{,}713 - \$6{,}750 \\ &= -\$10{,}463 \end{aligned}$$

Note that, where the probabilities are conditional, this amounts to adding up the values under the re-

**TABLE III—Decision Design—Purchase of Stone Cutting Saw**

| | Alternatives | Approve | | | Disapprove | | |
|---|---|---|---|---|---|---|---|
| | Outcomes | Obtain advantages claimed | Obtain less than claimed advantage | Fail to obtain advantages | Fail to obtain advantages | Incur Further Losses | Lose the Business |
| a. Decision Based on Probability Only | Probability of Outcome—In Order of Size | (1) | (2) | (3) | (1) | (2) | (3) |
| | Cost—$ | −6,570 | −6,570 | −6,570 | 0 | 0 | 0 |
| | Return*—$ | 22,350 | 11,175 | 0 | 0 | −12,375 | −67,500 |
| | Net | 15,780 | 4,605 | −6,570 | 0 | −12,375 | −67,500 |
| b. Decision Based on Desirability | Probability of Outcome, p | 0.5 | 0.4 | 0.1 | 0.6 | 0.3 | 0.1 |
| | Cost—$ | −6,570 | −6,570 | −6,570 | 0 | 0 | 0 |
| | Return—$ | 22,350 | 11,175 | 0 | 0 | −12,375 | −67,500 |
| | Net | 15,780 | 4,605 | −6,570 | 0 | −12,375 | −67,500 |
| | Value or Desirability (p × Net Return)—$ | 7,890 | 1,842 | −657 | 0 | −3,713 | −6,750 |
| c. Decision Based on Variable Probability | Probability of Outcome, p | 0.4—0.6 | 0.3—0.5 | 0—0.15 | 0.5—0.7 | 0.2—0.4 | 0.1—0.2 |

*Over useful life of equipment, 15 years.

spective alternatives. The higher mathematical expectation points to the choice of the alternative of approval. Here again, some policy restriction regarding significant differences in expectancies might reasonably be applied. It is suggested that an appropriate limitation might be that the difference between the highest and lowest expectations, reduced to an annual basis, shall not be less than 25 percent of the cost. For the example,

$$[\$9{,}075 - (-\$10{,}463)]/15 = \$1{,}303$$

which is 20 percent of the cost ($6,570). Therefore, the decision to approve is marginal according to this rule.

A sixth and final rule makes it possible to arrive at a decision combining loss-control with mathematical expectation when reliable information about the probabilities is not available. This rule can be applied in the absence of reliable information about probabilities (i.e., a range of probabilities may be used). It combines loss-control with mathematical expectation. Table IIIc is modified to show a range of probabilities under each outcome.

The mathematical expectations may be calculated using the lower bound of the most probable outcome, the upper bound of the least probable outcome and adjustment of other contingent probabilities, within their bounds, to give a total probability of 1.0. If approved, the mathematical expectation of the value is:

$$\begin{aligned} E_A &= (0.4 \times \$22{,}350) \\ &\quad + (0.15 \times 0) \\ &\quad + (0.45 \times \$11{,}175) \\ &\quad - \$6{,}570 \\ &= \$8{,}940 + \$5{,}029 - \$6{,}570 \\ &= \$7{,}399 \end{aligned}$$

If disapproved:

$$\begin{aligned} E_D &= (0.5 \times 0) \\ &\quad + (0.2 \times -\$67{,}500) \\ &\quad + (0.3 \times -\$12{,}375) \\ &= -\$13{,}500 - \$3{,}713 \\ &= -\$17{,}213 \end{aligned}$$

The higher expectancy for approval indicates that it is the alternative that should be accepted. Applying the usual policy qualification, as before,

$$[\$7{,}399 - (-\$17{,}213)]/15 = \$1{,}641,$$

which is just 25 percent of the cost. The proposal would be approved as the basis of providing a satisfactory return on investment and protecting the company against possible losses.

This final rule appears to be a very satisfactory one for dealing with decisions of the sort considered. It employs probability concepts without requiring extremely fine determination of the probability of each. It introduces control of losses, which is not taken into account when only the positive alternative outcomes of a decision are considered. It implies most complete utilization of the available data having a bearing on the decision.

Having a rule like this and applying it conscientiously has other secondary advantages. By focusing attention on the estimation of probabilities, costs, and returns, application of the rule should increase the ability to make valid estimates of these elements of decision. In other words, the very existence of rules and a system for applying them should aid in improving the data fed into the design. It emphasizes the necessity for doing things about getting progressively better and better data.

The six rules that have been illustrated are tabulated in Table IV to summarize this section and to make them readily available for reference.

### *Proof of the Data by Quality Control*

If it turned out that the cost and savings estimates used in the decision design procedure did not come

## *SECOND TECHNICAL CONFERENCE OF CHEMICAL DIVISION*

The Chemical Division, with the Buffalo Section as host, will hold their second Technical Conference Oct. 2-3 at the Hotel Statler-Hilton, Buffalo, N. Y. The program will present 16 technical speakers in two simultaneous sessions, who will cover a range of subjects from fundamental applications to the most sophisticated methods. Registrants with all degrees of background are assured of valuable technical content which will meet their interests and needs.

A special feature will be four seminars, running as a third session, patterned on the American Management Association seminars. Attendance at these seminars will be limited to 25 in order to encourage each person to contribute in open discussion. The four seminars and their chairmen are:

**I. Statistics in the Analytical Laboratory**
C. T. Shewell, Refining Research and Development Division, Humble Oil & Refining Co., Baytown, Texas

**II. Statistics in Processing Operations**
E. F. Schultz, Plastics Division, Dow Chemical Co., Midland, Mich.

**III. Evolutionary Operation**
T. L. Koehler, Organic Chemicals Division, American Cyanamid Co., Bound Brook, N. J.

**IV. Statistics in Subjective Testing**
O. Dykstra, Jr., Research Center, General Foods Corp., Tarrytown, N. Y.

The chairmen solicit suggested problems in advance.

Luncheon speakers will be Dr. T. H. Brown of Harvard University School of Business Administration, and Dr. C. C. Furnas, Chancellor, University of Buffalo. The latter will speak on "The Practicing Scientist's and Engineer's Role in Improving Education."

An all expense tour to Niagara Falls, Ontario with dinner and cocktails at the Sheraton-Brock overlooking the mighty cataract will be available Thursday night, Oct. 2.

For further details see page 34 in this issue, and mark the date. Whether you are employed in the chemical and allied industries or not, you will find the Conference valuable.

The program follows:

*Fundamental Control Concepts*, M. E. Wescott, Rutgers University
*Acceptance Control Charts*, C. H. Chandler, Eastman Kodak Co.
*Tests of Significance*, F. C. Leone, Case Institute of Technology
*Interval Estimates*, J. S. Hunter, Princeton University
*Simple Factorial Experiments*, F. R. Sheldon, Becco Chemical Division, Food Machinery & Chemical Corp.
*Basic Experimental Designs*, H. Davidson, Merck & Co.
*The Control of Related Variables*, J. E. Jackson, Virginia Polytechnic Institute
*Range Techniques*, A. J. Duncan, The Johns Hopkins University
*Analysis of Residuals*, F. J. Anscombe, Princeton University
*The Role of Formal Experimental Design*, S. L. Crump, University of Rochester
*Empirical Models*, M. B. Wilk, Bell Telephone Laboratories
*Applications of the Digital Computer to Chemical Problems*, R. H. Morris, Eastman Kodak Co.
*Panel Discussion of Difficult or Unusual Problems*, E. J. Delate, E. I. duPont deNemours & Co., and W. J. Youden, National Bureau of Standards

**TABLE IV—Some Frequently Applied Decision Rules***

1. Choose the alternative for which the return of the most probable outcome is largest.
2. Choose the alternative which *could* lead to the largest return.
3. Choose the alternative with the most favorable of the least favorable returns under the respective alternatives.
4. Choose the alternative for which an outcome has the largest numerical value or desirability.
5. Choose the alternative with the largest mathematical expectation.
6. Choose the alternative associated with the largest of the least favorable expectations.

*With the exception of Rule Number 4, these are from the work Bross: *Design for Decision*, The Macmillan Company, New York, 1953.

from controlled data sources, the method of solution itself would be suspect. The proof of the data by statistical quality control is, therefore, one of the most important steps that needs to be taken.

Fortunately, since the subject of administrative applications of quality control has received wide attention, methods for determining whether the data are controlled have become well known. Follow-up procedures for improving uncontrolled estimates will depend upon the nature of the records kept and of management practices in use. This is a large but manageable problem, which could provide material for not one, but several articles. It is assumed that before the decision design procedures are applied, steps will be taken to assure that the necessary conditions of control in the data have been met.

One specific way in which statistics can help to improve the basic data used in decision making is through the application of the concept of statistical control charts to the difference between estimates of costs and returns and the actual costs and returns obtained. The availability of historical data for this purpose depends on the existence of good records, particularly of unit costs. The manager, faced with making a decision, needs to have confidence that the estimating procedures are in control in a statistical sense. He will, therefore, have to insist on maintenance of adequate records and on the employment of statistical quality control principles to eliminate the occurrence of erratic estimates. This is not difficult to do, once its value is understood. For example, electrical construction estimates have been studied by control chart means.[2] The differences between estimates and actual costs for a large number of jobs were tabulated. When these data were plotted on control charts, it was possible to determine the degree to which the work of the estimators was inconsistent, or not controlled. Also, the limits could be used to determine how well acceptable performance standards were being met. In that study, the differences between estimates made by the central engineering department and by plant engineers were clearly pointed out. Also, reduced variability between estimate and performance as the result of introduction of a manual of standard unit cost data could be measured.

Approximately one hundred separate estimates were available, divided equally among material estimates and labor estimates. There was also approximately equal division among plant engineering department estimates and central engineering department estimates, both before and after introduction of the standard cost manual. Only the plant estimates showed lack of control, and then only on the range chart. This indicated lack of consistency between different estimators.

However, the most important information given by the charts was that although inconsistent practices resulted in very wide limits in all instances, there was a very marked decrease in the spread of limits from plant estimates to central engineering estimates, and from central engineering estimates before to estimates from the same source after publication of the standard costs. In terms of the upper limit for the average charts, with plant estimates indexed as 100, the results were as follows:

Plant Estimates: 100

Central Engineering Estimates

Without Unit Costs: 72

With Unit Costs: 30

## Conclusion

In making decisions of the type described, managers have generally supplemented meager data with the use of intuitive judgment. Intuition may be fortified by the scientific handling of quantitative data. This fortification may take the form of systematic "designs for decision." The use of a systematic approach focuses attention on the estimation of probabilities of success and failure and on the validity of estimates of costs and savings. Improvement in the estimation of probabilities is the real crux of this matter. It is achieved through unrelenting effort to approach reality, as well as through experience.

In general, great confidence is put in the validity of engineering estimates of costs. Sometimes these can get out of line, but with reasonable care and adherence to sound managerial policies a satisfactory result is usually achieved. The validity of estimates of savings is somewhat

**Work Sheet—Decision Design**

| Project: | Subject: | | | | | |
|---|---|---|---|---|---|---|
| Alternatives | | | | | | |
| Outcomes | | | | | | |
| Probability, p | | | | | | |
| Return, $ | | | | | | |
| Cost, $ | | | | | | |
| Value, $ | | | | | | |
| Decision | | | | | | |

1. Useful life:
2. Return during useful life:
3. Detail of Probability and Return:
4.
5.
6.
7.
8.
9.
10.
11.
12. Expectations:
13. Alternative:
14.
15. Alternative:
16.
17. Sum of Expectations ÷ Useful Life:
18. Line 17 ÷ Cost:
19. Remarks:

more open to question if only because of a very natural tendency to make a proposal appear as attractive as possible. It is suggested that quality control charts may be used to determine the consistency of differences between estimates and actual savings. It is worthwhile to consider means of making information on actual savings more available. A routine follow-up using quality control methods will make it possible to find the assignable causes of exceptional deviations between estimates and experience and lead to progressive improvement in the correctness of estimates and hence of decisions based on them.

The techniques recommended may appear to be complex. However, the effort required to use them is small compared to the economic value to the company and the enhanced reputation of the decision-maker that would ensue were statistical aids utilized fully.

### References

(1) Irwin D. J. Bross, *Design for Decision*, The Macmillan Company, New York, 1953
(2) Charles A. Bicking, "The Control Chart as a Tool in Management," paper presented at 104th Annual Meeting of the American Statistical Association, Washington, D.C., December 29, 1944

### Acknowledgment

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# Quality Control at the Crossroads

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## Introduction

The consistent growth of science and technology during the last decade has been dramatically brought to the world's attention in the past few months with the advent of practical new devices which promise to make space travel possible. The rapid growth of scientific and technological information since the introduction of "Sputnik" has highlighted a series of problems which were not so obvious during the period when the United States and its allies were in a position of undisputed leadership, militarily, as well as, economically and politically. Since the launching of "Sputnik," a number of sober and thorough re-examinations have been made by several governmental and non-governmental agencies concerning the effect of this dramatic Soviet effort on our own military and political situation. These studies have all considered the opportunities for improving our relative status through measures capable of restoring the United States to a position of unchallenged leadership.

### Editorial Note

This report was submitted at the February 1958 meeting of the Small Business Industries Advisory Committee to the Department of Defense. It was well received by that body and the proposals which it contains are now being studied by the Department as well as its agencies. The author served as Chairman for two Quarterly sessions of this Advisory group and also is the president of Genisco, Inc.

### Tasks for Industry

Certain critical tasks are already clearly defined for American industry and for the military establishment. They include an intensification of the efforts, which have been underway for many years, to build more effective striking forces capable of successfully preventing the expansionist designs of the Communist block and capable of quickly overpowering enemy forces in the event that war should actually come. The problem is not simply one of "crashing through" with important and dramatic new weapons. Although these can certainly have great military and even political significance, the total striking power of our military and the general level of preparedness of our industrial establishment are the ultimate factors which will determine the final outcome of any cold or hot war. It is to be expected that new demands will now be made on the scientific and engineering capabilities of American industrial and military organizations. We have already had some considerable experience with respect to the extremely complex nature of the new weapons systems and the tremendously difficult performance requirements which these systems must achieve. It would appear that industry will have to exhibit its greatest vitality and ingenuity to meet the operational requirements for these new devices.

### *The Role of Quality Control*

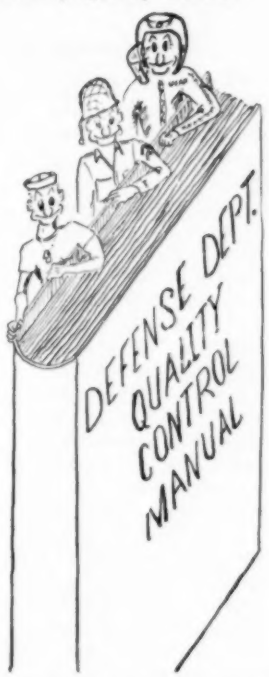
One of the most valuable weapons available in the arsenal of modern industrial management is that body of engineering, production and inspection techniques generally called Quality Control. But the tasks ahead for Quality Control are themselves qualitatively greater than any previously met by this approach because industry must enter areas in which the manufacturing processes are expected to yield quality levels previously unknown and component and system reliabilities the like of which were almost unthinkable less than ten years ago. With this much of the problem known, it is the purpose of this report to explore the present status of Quality Control within the small business community serving the Defense Department and the relationship of this apparatus to the government contracting agencies and the major prime contractors. The purpose of this exploration, simply stated, is to indicate those areas related to Quality Control which require improvement or clarification in order to guarantee the success of the objectives of defense industry.

## Summary of Report

Quality Control is the name given to those methods which are used for the purpose of defining, measuring and regulating manufacturing processes and products. These methods are aimed at preventing, wherever possible, the production and delivery of materials or products which are not acceptable to the customer, or which do not function properly after delivery. With the need for new and much more complex weapons systems, there has been a tremendous increase in the level of military quality requirements. This has, in turn, greatly increased the need for better and more successful methods of Quality Control, particularly in those areas of product quality which are related to overall weapons system reliability and component performance. It should be noted that, while the cost of the new weapons being developed today is already very high, any failure or shortcoming due to poor Quality Control, not only increases this cost, but also reduces the value of the weapon to the vanishing point.

### *Unify the Approach to Military Quality Control*

The objectives and fundamental point of view of the various service branches and the leading prime contractors regarding acceptable Quality Control systems should coincide more than they do at present. Greater emphasis should be placed on making the main task of military Quality Control one of evaluating and monitoring the producer's own Quality Control System. Less emphasis should be placed on the concept of government Quality Control as a parallel system for simply re-inspecting and re-testing products and components. In addition, the inspectors utilized to carry out the tasks of evaluating the Quality Control systems of the government's sources should be men of considerable practical experience, operating, as far as possible, with a uniform and explicitly stated approach to those areas of company performance requiring their personal judgment. These men must be capable of recognizing the relative suitability of various methods of Quality Control to specific industrial situations.




### *Use Quality Control in Industry to Improve Quality Levels and Product Reliability*

The difficult design, test, and production tasks now facing defense industry have been brought into sharp focus by the developing international situation. There is now an equally apparent obligation for industry to master those Quality Control methods which are most appropriate for the swift and fruitful accomplishment of these tasks. One of the leading problems is that of sharply raising the general Reliability and Quality level of the devices and components now being furnished to the military. *The ability of industry to describe, predict, and control the behavior of the equipment which it is responsible for creating must be systematically advanced.* The outlook and methods of Quality Control must be appropriately integrated into every aspect of design, prototype development, production, shipment, storage, and maintenance so that the accomplishment of these tasks may be achieved at minimum expense to the government, but with a firm assurance that they represent the highest possible level of industrial accomplishment.

### *Encourage Initiative in Small Business*

For small enterprises, with their many specialized skills and personalized administration, the opportunity for a display of ingenuity in achieving remarkable new levels of quality should be encouraged by giving the widest latitude to these talents. Those organizations which have not yet developed a mature Quality Control organization should receive maximum support and assistance from government, industry, and the technical associations in developing and applying Quality Control methods suitable to their own needs.

### *Improve Government Information Sources*

Information exchanges, instruction guides, and an explanation of the advantages and limitations of various Quality Control techniques should be widely disseminated, together with much more complete information on the most successful and acceptable means of records preparation, etc. As the various service branches develop more uniform approaches to the handling of Quality Control problems, these should be incorporated into information sheets or directives and widely distributed to sub-contractors and primes so that the basis of government policies on Quality Control may be understood by all.

# The Viewpoint of Quality Control

The methods of Quality Control are intended to support the most important task of industry. This is the responsibility for reliably and economically creating products and services which are of good quality. Quality Control enters the picture in the accomplishment of this job through its specialized approach to the problems of how quality is defined, how its various aspects are measured, how its sources are determined and maintained, and how deviation from acceptable quality can be detected and minimized.

Without attempting to turn this study into a recitation of the contents of the many fine texts on Quality Control methods, a few of the basic propositions of the Quality Control viewpoint are listed here.

### *What is Quality?*

The word quality is often misused and misinterpreted. It is commonly connected with the idea of "deluxe" or "high class". This is a misleading and incomplete notion. Quality may refer to "ordinary" or "acceptable" just as easily as it refers to "fine," depending on the customer's requirements. Actually there are two different things which may be described by the word quality—the product and the process used to generate the product. In either case, the term is applicable only if the process or product meets a specific need or requirement for which it has been designed. A common illustration of the achievement of quality is a machined part which has all its dimensions within the tolerances called out by the engineer on his drawing of the part. There is often more than one way to deviate from a quality specification. A part can be too long or too short and a product can be too fine or too coarse to accomplish its intended purpose. Quality, then, is *a measure of how close the product comes to what is wanted.*

### *Acceptable Product Variability*

This definition of Quality implies a number of important things. In the first place, it indicates that the output of a manufacturing process is not identical units of product, but individual items which are essentially similar in their degrees of variation one from the other with respect to their ability to meet a given set of specifications. That is, no manufacturing process yields identical units, but there is in any process a certain variability of product quality which is to be expected and which is permissible. Of course, this definition of quality implies that the basic requirements of the product can be determined and stipulated, in a specification so that some concrete comparison may in fact be made between any particular unit of production and the permissible range of variation of any aspect of product quality.

### *How Quality Control Functions*

Having considered what it is that determines product quality, and the fact that product characteristics may be permitted to vary, within limits, the tasks of Quality Control may be approached. These begin, generally, with studies which determine the compatibility of the specified tolerances with the normal variations produced by the manufacturing process. The problem is one of determining whether the process can produce as is expected. If the process cannot regularly produce within specifications, then the manufacturer must either change the process or the specifications, or decide to produce a certain amount of below-standard product. Once an acceptable process has been developed, the next task involves regularly re-examining, by one of a number of available methods, whether the process is continuing to produce within its acceptable range of variability or has changed to such a degree that the specification will not be met unless corrective action is taken. *Quality Control is devised mainly for encouraging the making of product which is acceptable and for sounding the alarm when bad product starts to be produced.*

### *Other Responsibilities of Quality Control*

In addition, Quality Control organizations are interested in examining the relative importance of the various quality characteristics of a product, as well as the assessing of the quality of the work performed by the company's vendors, evaluating lots of finished product, devising methods by which quality records may be kept, and disposing in an orderly fashion of those materials which have been found to be outside the limits of acceptability. Quality Control is also concerned with evaluating the effect on product quality of design changes and with maintaining the inspection and test equipment in an adequate state of usefulness and calibration. These and many other activities which form the substance of modern Quality Control, are all aimed at generating production which meets the requirements of the consumer without creating the need for excessive sorting out of bad product. A secondary purpose of Quality Control is the collection of information regard-

ing production process variability and capability which may act as a guide in setting future specifications of related products. In industries where product re-design and improvement are important, this kind of information is indispensible.

In summarizing the many objectives and activities which characterize a well-rounded Quality Control installation, Mr. A. V. Feigenbaum, one of the country's leading Quality Control specialists stated in a recent issue of the Harvard Business Review:

> *"Total Quality Control represents another forward step in management science. Its integration of design-through-shipment control of the many elements of a quality picture makes it much more effective than the unlinked fragmentary controls of the past . . . Inspection and test . . . (thus have an opportunity to serve) a positive role in assisting other members of the manufacturing, engineering and marketing team toward quality improvement and quality cost control."*

### *Military Quality Control Programs*

Since the days of the second World War, all military organizations in the United States have recognized the importance of and, to one degree or another, have insisted upon, quality control programs in the factories which supply their military goods. Such programs have, in many cases, been remarkably successful in reducing scrap and waste, as well as saving the government from the agonizing experience of ordering and depending upon materials which turn out to be sub-standard upon completion. In spite of the success of Quality Control methods in these companies, there are many producers of military supplies who look upon Quality Control as an artificial device which must be present in a plant in order to "please" the procurement agencies. These plants often have established the outward appearances of a Quality Control program without any of the real benefits that come from scientific control over the manufacturing process. In other words, many companies barely tolerate Quality Control systems in their factories without really adapting these techniques to the particular requirements of the plant itself. In some instances the words "Quality Control" are simply used as a synonym for inspection. The essential viewpoint of Quality Control as a company-wide responsibility with continuous feed-back of information and adjustment between engineering, production, and inspection to prevent waste, reduce sorting, and generally improve uniformity of product, is missing in these factories.

### *Integrating Industrial Quality Control Methods*

This problem is not a private matter, but one of general concern, since the control of quality of military products affects the safety and welfare of the entire nation. It seems imperative, therefore, for the military services to join with industry and the technical-professional societies in a concerted effort to promote the integration of appropriate Quality Control methods in those companies where they can serve to strengthen the work of the Defense agencies by making possible greater conformity of product to specifications. Such an effort can be a greater boon to the improvement of this country's capacity to defend itself than the development of a powerful new weapon. This is true because better Quality Control is a guarantee that industry can regularly supply all the needs of the armed services.

It must be recognized, however, that successful Quality Control methods require real cooperation from management. Here, as in so many areas, the greatest progress will be made when participation is entirely voluntary and based on real study and understanding of how to relate general Quality Control principles to specific problems of individual companies.

### *Improving Communications*

There appears to be a great need for the procurement agencies to re-examine the communications links between government and industry. Often, the firm which has not had extensive experience with Quality Control comes to look upon the insistence of the military for quality records, lot identification, material review techniques and the like, as necessary evils, because their function is not adequately understood. In meeting the language difficulties which are created when a government directive is couched in intentionally generalized terms, it might be well to cite concrete experiences and practices of individual companies. What may seem abstract and ambiguous in a formal directive or specification, can come to life in a case history. Whatever methods are used to improve communications, the reasons behind military requirements should always be made clear to the contractor.

### *Clinics and Conferences*

Another technique which can have great merit in relating the approach of Quality Control to the needs and interests of many companies is the further encouragement of industry—or area-wide clinics with military, prime and sub-contractors present, where fruitful approaches may be demonstrated and discussed regarding particular quality problems. While it is certainly not the job of government to show industry how to operate successfully, it can be a great boon to everyone if the military encourages mutual exchange of experiences aimed at cooperative improvements in the control of quality. It should be expected that improvement in communications methods can become a two-way street which will not only contribute to industry, but also to the military, the experiences of various companies regarding such problems as the need for improvement of production process specifications and the results of recent efforts towards the accomplishment of particular tasks in the field of utilizing Quality Control techniques.

# Changing Objectives of Military Quality Control Programs

### *100 Percent Re-Inspection*

In an earlier day it was the common practice of service organizations when they purchased military equipment from private industry to inspect this equipment thoroughly, even if this meant duplicating the efforts already made by private industry. Throughout World War II it was not unusual for military inspection organizations to design their own gages, interpret blueprints and specifications and conduct independent parallel inspection either at the supplier's plant or in the arsenal or depot where the end-product was received. In some cases this activity extended to re-inspection of piece parts and components, as well as end-products. The practice of detailed 100 percent re-inspection was, of course, often not adequate to remove sub-standard units from those which the government accepted for purchase.

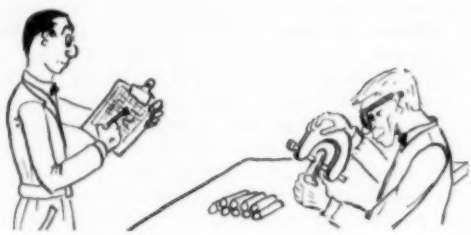
### *Sampling Re-Inspection for Acceptance*

With the advent of modern Quality Control, the attention of military inspection organizations has been turned more and more in the direction of statistical sampling. This approach is designed to serve the dual purpose of supplying information with regard to the production process quality average and at the same time offering a relatively reliable and inexpensive means for making decisions regarding the acceptability of completed lots or units. Those government agencies which still utilize 100 percent or sampling re-inspection techniques to determine the acceptability of the contractor's efforts also often undertake the responsibility of determining their own Standard Inspection Procedures, Classifications of Defects, and Acceptable Quality Levels. Sampling has proven to be superior to 100 percent re-inspection and re-testing methods because it standardizes inspection procedures used by the government and generally permits only acceptable lots to be purchased by the government. Most important, *sampling re-inspection places the main responsibility for the submission of acceptable quality on the shoulders of the producer of the material.*

### *Surveillance Inspection*

As a matter of practical economy and in order to further establish the notion that the main responsibility for meeting contractual requirements resides with the producer, an advancement over detailed sampling re-inspection has been made in the past few years. This advancement is generally called "surveillance inspection". It is based on the proposition that *the contracting agency can determine whether a supplier has met his specified requirements through the use of objective evidence which is obtained by the contractor and then verified and evaluated by the military Quality Control representative.* The Air Force, which has been a foremost proponent of this point of view, feels that it can no more match the inspection activity of its producers than these producers can duplicate the inspection facilities of their own suppliers. They, therefore, prefer to purchase, together with the product for which they have contracted, the service which is supplied by the contractor's Quality Control system. They then proceed to critically examine this system and the test records, reports, and inspection certificates which are generated in producing the required equipment or supplies.

The military Quality Control representative will in some cases, actually re-inspect or re-test the finished product. In other cases he will simply witness the tests in order to assure himself of the authenticity of the company's records and procedures. The Air Force representative does not, however, assume the responsibility for writing classifications of defects or establishing quality levels. The total amount of surveillance which is carried on in any particular contractor's facility is directly related to the relative importance of the product being made and the effectiveness of the Quality Control program of the contractor. This effectiveness is evaluated by the Quality Control representative and subsequently is reviewed by a survey team made up of several specialists, familiar with the particular product involved and with the use of adequate Quality Control procedures.



### *Advantages of the Surveillance Approach*

It appears entirely logical to the Air Force and certain elements in the Navy, that the companies which have been given the responsibility in the first place for designing and manufacturing articles of military equipment, should also be given the major responsibility for controlling the quality of their own products. Rather

than undertake the expense and difficult administration problems of placing a large force of government inspectors in a contractor's plant, the policy is now widely practiced of requiring that each contractor, having inspected and tested his products, will then proceed to furnish objective evidence to the government that all the requirements of the contract have been fulfilled. This evidence generally includes information regarding the conformance to pertinent specifications of raw materials and those steps through which they have been processed, the suitability of all parts, components and purchased items, the compliance with the requirements of all pertinent product design changes, and the accuracy of gages and test equipment used in evaluating product quality.

It has been pointed out by many leading industrialists that military suppliers have a continuing problem of combatting government tendencies to over-regulate the activities associated with the production of military supplies and weapons. By placing primary emphasis on the responsibility of the contractor for maintaining proper Quality Control in his own facility and in those of his vendors and sub-contractors, the Air Force has been able to reduce the red tape and duplication which characterizes detailed re-inspection. In addition to these advantages, the surveillance approach has opened many channels for the introduction of specialized techniques and advanced approaches to the improvement of quality that were largely inhibited by the more rigid procedures which they replace. American industry in general and small business in particular, has been quick to seize upon the flexibility of surveillance inspection as a means of bringing forward those improvements in processes and services which are most essential in this period of sharpened quality requirements. In the case of smaller industrial organizations, the advantages of precision craftsmanship, inventive ability, ingenuity in problem-solving, and close management supervision receive their greatest opportunity to exhibit themselves as a result of the encouragement which has been given by this approach, which makes no effort to restrict these creative capacities.

### *Military Quality Control*

While there can be no disagreement that each of the military services has needs and experiences which make their supply requirements unique, a serious difficulty has arisen from the unfortunate circumstance which sees no unified point of view presented by the Defense Department as a whole to the supplier, on the question of Quality Control. Several years ago the Assistant Secretary of Defense for Supply and Logistics, Thomas Pike, stated the basic objectives of military Quality Control in clear and unequivocal language.

> *"In achieving its primary objectives of assuring product quality, Inspection and Quality Control is to be viewed as a constructive activity directed towards the prevention of defects, the detection of unsatisfactory trends, the conservation of material, manpower and equipment, and towards the pooling of meaningful quality data for utilization in design, maintenance and production, and in supply management."*
>
> *"Since the ultimate measure of quality is effectiveness and reliability in service, the accurate and definitive evaluation of product quality necessitates the feed-back of performance quality information to Inspection and Quality Control for appropriate action and for use by other interested activities."*
>
> *"The objectives of Inspection and Quality Control are most effectively achieved in collaboration with, rather than by duplication of, other activities within both Government and industry. With respect to the latter, maximum utilization must be made of contractors' inspection and Quality Control information."*

In agreement with this viewpoint the Department of Defense Instruction 4155:6, states:

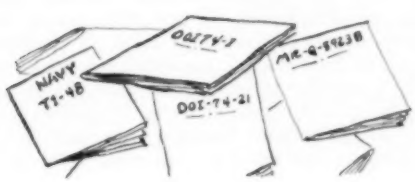
> *"Determination of conformance of product to contract requirements shall be made on the basis of objective evidence of quality and quantity. The Government inspector shall make optimum use of quality data generated by contractors in determining the acceptability of supplies."*

### *A Basic Military Quality Control Directive*

It would appear from these statements that a good foundation has existed for some time for the establishment of a single document which accepts these widely recognized principles and translates them into a unified Defense Department directive. Such an action would be particularly well received by those industrial organizations which find themselves conducting business either as prime or sub-contractors with several service branches. The many minor variations between such documents as the Air Force's MIL-Q 5923B and the Navy's T1-48, while generally only procedural, have created confusion, difficulty, and delaying red tape without in any way exhibiting any real advantage for either the Navy or the Air Force. In the case of Army procurement practices, a consolidation of existing Quality Control evaluation and acceptance techniques, stressing the viewpoint of surveillance inspection, could only serve to increase the efficiency and effectiveness of this branch of military Quality Control.

### *General Availability of Supplemental Directives*

In addition to the need for bringing together the military services under a single Defense Department Quality Control standard, it would also be valuable if many of the supplementary documents, such as the DOI-74-1 and DOI-74-21, were consolidated directly into these general specifications. *It has become increasingly important that the whole body of Quality Control specifications be made available in a single and complete document which can be studied and utilized by both the contractor and the military inspector.*



### *Defense Department Agreement on Need For Unified Manual*

Brigadier General Wm. P. Farnsworth, USAF, recognized in 1955 that the Defense Department had to undertake the task of translating the thinking and experience of the previous years into a uniform Quality Control Manual along the lines discussed here. Speaking for the Defense Department, he stated at that time:

> *". . . we will do two things: (1) prepare a Department of Defense Quality Control Manual incorporating the basic elements of an operational, management-directed quality control system, and (2) develop supporting techniques in the fields of administration, engineering and statistics. Fortunately, in these latter areas the departments of the Army, Navy and Air Force have done outstanding and prolific work. What is now needed is more widespread acceptance and general application of theoretical work and practical models already in existence."*

It is regrettable that in the intervening years since this fine suggestion was first put forward, our military organizations have been unable to develop and release this program and manual. It can only be hoped that in view of the even more pressing need, such a unified approach will appear in the near future.

### *Importance of the Military Quality Control Representatives*

As the concept of surveillance inspection receives wider application, it may be expected that the total inspection force now employed by the various military services can be reduced. The remaining military inspectors, whether they operate inside a single contractor's facility or in a wide area serving a number of smaller contractors, should be the most experienced and competent Quality Control authorities available to the services. These inspectors are the principle representatives of the government to the contractor and must be capable of using consistently good judgment and thorough understanding of the engineering and production aspects of their tasks in order to guarantee the best possible relationship between the government and the supplier. While it cannot be presumed that these men are experts in the products being manufactured, they can be expected to have extensive command of the techniques which lead to effective Quality Control.

## Reliability–Keystone of Modern Weapons

In the period since the introduction of missiles as the core of both offensive and defensive weapons systems, increasing attention has been paid to the problem of reliability. Of course, every man-made device has some degree of unreliability. The problem is to greatly reduce those factors which lead to failure in the application and operation of modern weapons. Essentially,

> *"reliability is the probability of a device performing its purpose adequately for the period of time intended under the conditions encountered."**

The interest which the military services have in studying, measuring and learning to control the performance of the new weapons systems is neither casual nor academic. After years of effort and millions of dollars in defense expenditures, in the last analysis, the very safety of the country depends directly on the degree to which these weapons are capable of meeting the actual conditions under which they must operate and accomplishing the vital purposes for which they are intended.

Mr. W. W. Wooldridge, Vice President of Hughes Aircraft, recently stated the problem very succinctly:

> *"We are bound by our formula of national defense to work on the basis that there can be no excuse for product failure. Indeed, we cannot expect to have the time to make an excuse for failure."*
>
> *"The weapons and weapon systems we employ must work precisely as they are intended to work—they must do the job of keeping an enemy off our heads—and they must do it on an instant's notice, thoroughly and efficiently and with no margin for error. One error, in the age of the H-bomb, means certain disaster."*
>
> *"We must make sure that such an error cannot possibly be permitted by failure of some electronic or mechanical device, small or large, simple or complex."*

*The Systems Reliability Analysis Task Group of RETMA, *A General Guide for Technical Reporting of Electronic Systems Reliability Measurement.*

### *Detailed Inspection Not Adequate*

Many of the men who have been responsible for the design and production of such weapons recognized from the outset that ordinary 100 percent inspection of parts and components was inadequate to meet the need for high quality. The inspection approach assumes that high quality products can be "sorted-out" of "regular" production runs. However, it is well known that inspection cannot be expected to eliminate all the bad products.

The use of Quality Control methods is a great improvement over 100 percent or even 200 percent inspection because it aims at controlling the manufacturing process in order to prevent off-standard parts and products from ever coming into existence. Quality Control not only controls production, but also serves to improve the uniformity and over-all reliability of components and products. In this respect it contributes greatly to the task of raising product quality levels.

### *False Economy Can Impede Quality Improvement*

There is one aspect of Quality Control which needs to be greatly modified in order to meet the requirement for preventing even very small quantities of defective material, as is required, for example, in the production of missiles. Quality Control often permits some compromise between the quality level which is originally demanded and the relative cost of the product, in order to achieve an economic balance between the customer's needs and his ability to purchase the product. A compromise is generally made which seeks to control product performance within specified limits. In the manufacture of the new weapons systems this compromise becomes intolerable because of their critical importance. Instead, each component must be continuously improved and its working relationship with other components continuously evaluated. In the missile industry, the maximum level of reliability is also the most economic level of operation,

considering the importance and expense of failure. *Thus, the purpose of the weapons rules out the familiar economic approach to Quality Control.*

### *The Need for Systematically Meeting More Rigid Specifications for Components*

Increasing the quality level of missile components in order to improve the performance of the missiles themselves requires a complete re-examination of the test values, safety factors, and environmental conditions which governed component evaluation in the past. It cannot be assumed that "normal" approaches properly test the real conditions which the new weapons will encounter when they are placed in service. Once these factors have been thoroughly re-evaluated it becomes necessary to test a statistically significant number of completed weapons and components to the point of failure. Such a program, starting in the early stages of the weapon's development, will indicate those weaknesses of components and component inter-relationships, which must be corrected or improved long before a new weapons system becomes operational. In this way very high component reliability levels may be achieved and maintained.

### *Independent Component Improvement Programs Required*

Mr. Wooldridge, in the report mentioned above, pointed out a critical fallacy in the approach now being taken to the improvement of weapons reliability.

> *"We establish the need for a formidable new system and then start looking around for the parts to put it together. It has been very difficult to get money for research leading to parts development until a definite equipment application is in sight. This is too late. The systems designer must decide whether to use proven but less than adequate parts or to throw his hat at developments that are still on the horizon. Some unhappy results have come from following the latter course.*
>
> *No one company or project carries enough weight to move the parts manufacturing industry toward the broad advances demanded by the tasks we are attempting. An expanded research program is needed, if we are to develop the bits and pieces for tomorrow's equipment."*

This program can be most successful if it represents a cooperative effort between the military research agencies and the individual small enterprises which are presently engaged in component production.

### *Reliability Studies Must Begin Early*

Performance reliability studies can determine, all along the road in the development of new weapons, the effectiveness of various measures designed to improve ultimate weapon reliability. Even after the completion, delivery and warehousing of weapons, reliability studies must be used to evaluate the results of proposed preventive maintenance schedules which are designed to protect the reliability of aging equipment.

It is easy for industry and the military services in the rush of weapons development programs and with the pressure to meet deadlines, to succumb to the mistaken notion that component reliability can somehow be introduced into a weapon in its later stages of development and production. Experience has shown that this is a vain and dangerous delusion because, particularly in the modern approach, which generally assigns weapons systems responsibility to a single prime contractor, there is a marked tendency to "freeze" the design of many components once a system has been released for production, in order to stabilize tooling and the production processes. The postponement of improvements in component performance to a later stage in the program can easily lead to permanent hazards and flaws remaining in the weapon after it reaches the operational stage. The need for changes and improvements at this stage are often difficult to analyse and can greatly increase the final cost of the weapons program. In addition they can seriously delay the operational availability of the weapons themselves.

### *Apparent and Real Cost of Reliability*

Early and complete reliability improvement programs for the many components which make up a weapons system, may greatly increase the apparent cost of the system. In many cases the cost of an individual component, after it has been systematically improved to meet the needs of the weapon in which it is to be used, will be considerably higher than that of more conventional, but less reliable, components. In the final reckoning, however, the critical performance of the new weapons depends directly on the ability of military and industrial weapons authorities to recognize the need for systematic component improvements. The cost of servicing unstable equipment, making necessary modifications in the field and correcting inoperable or poorly operating equipment often greatly exceeds the original cost of the weapons themselves. Real economy, in this case, cannot be reckoned in any other terms than the need for absolutely dependable weapons.

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# Production Scheduling in a Canning Plant

C. T. SHEWELL and H. C. EDWARDS*

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In operating a canning machine, which is filling one quart cans with lubricating oil, it is frequently desirable to can more than one brand of oil in a day's operation, and since most brands of oil are marketed in more than one grade, it is usual to can all grades of any brand in sequence so that the empty can feed need be changed only when a brand is changed.

For example, Humble markets two grades of Esso Extra motor oil, two grades of 997 motor oil, and three grades of aviation engine oil, among others. Each brand of oil is contained in distinctively different lithographed cans, the grade being stamped in the top lid as the lid is fed into the can sealer. Changing cans loses about 15 minutes of production time; changing grades about 10 minutes. A canning machine will fill about 400 cans per minute, and the cans are then packed 24 to a case for shipping or holding in inventory.

The maufacturers of cans do not like to ship less than 20,000 cans of any one brand, as set up time on their production lines is such as to make smaller orders uneconomical. Thus the shortest canning run at the refinery must be at least 833 cases of any one brand, split into as many grades as desired.

*Mr. Edwards is presently employed by Texas Instruments, Inc., Dallas, Texas.

Since changing grades within a brand involves the least amount of lost production time, it is usual practice to schedule production so that each grade of a brand is canned in a continuous run, the split between grades being guessed in an effort to have the reorder points of all grades in that brand occur at the same time. The split between brands is also guessed in an effort to have, say, three week's inventory of brand A and six month's inventory of brand B on hand at current estimated sales rates.

Let it be assumed that two brands are to be canned, with three grades in brand A and two grades in brand B. Table I shows the estimated sales rates and current inventories.

After the proposed production, the new inventory of brand B is to satisfy demand three times longer than brand A.

TABLE I

| Brand & Grade | Inventory, I | Sales Rate, S |
|---|---|---|
| $A_1$ | 5 | 23 |
| $A_2$ | 3 | 13 |
| $A_3$ | 24 | 5 |
| Total for A | 31 | 41 |
| $B_1$ | 15 | 21 |
| $B_2$ | 12 | 17 |
| Total for B | 27 | 38 |
| Grand total | 58 | 79 |

Let $\pi$ be the number of periods protected by inventory, I the current inventory, P the amount of production and S the current sales rate, then

$$\pi = \frac{I_{A_1} + P_{A_1}}{S_{A_1}} = \frac{I_{A_2} + P_{A_2}}{S_{A_2}} = \frac{I_{A_3} + P_{A_3}}{S_{A_3}}$$

$$= \frac{\Sigma I_A + \Sigma P_A}{\Sigma S_A} \qquad (1)$$

or

$$P_{A_1} = (S_{A_1})\pi - I_{A_1} \qquad (2)$$

also

$$\pi = \frac{I_{B_1} + P_{B_1}}{3S_{B_1}} = \frac{I_{B_2} + P}{3S_{B_2}} = \frac{\Sigma I_B + \Sigma P_B}{3\Sigma S_B} \qquad (3)$$

or

$$P_{B_1} = (3S_{B_1})\pi - I_{B_1} \qquad (4)$$

Therefore

$$\Sigma P = (\Sigma S_A + 3\Sigma S_B)\pi - \Sigma I$$

or

$$\pi = \frac{\Sigma I + \Sigma P}{\Sigma S_A + 3\Sigma S_B} \qquad (5)$$

The first step is to utilize equations (1) and (3) as inequalities to determine the minimum $\pi$; that is,

$$\pi \geq \frac{\Sigma I_A + \Sigma P_A}{\Sigma S_A}$$

$$\pi \geq \frac{\Sigma I_B + \Sigma P_B}{3\Sigma S_B}$$

Using the values of I and S from Table I, the minimum production for any brand is limited by the can manufacturer's minimum run of 20,000/24 or 833 cases. Therefore $\pi \geq (31 + 833)/41 = 21.09$ or $\pi \geq (27 + 833)/3(38) = 7.54$. Since $\pi$ must be greater than the larger of these inequalities, the integral value for minimum $\pi$ is then 22.

**TABLE II—Feasible Production Schedules**

| $\pi$ | $P_{A_1}$ | $P_{A_2}$ | $P_{A_3}$ | $\Sigma P_A$ | $P_{B_1}$ | $P_{B_2}$ | $\Sigma P_B$ | $\Sigma P$ |
|---|---|---|---|---|---|---|---|---|
| 22 | 501 | 284 | 86 | 871 | 1371 | 1110 | 2481 | 3352 |
| 23 | 524 | 297 | 91 | 912 | 1392 | 1127 | 2519 | 3431 |
| 24 | 547 | 310 | 96 | 953 | 1413 | 1144 | 2557 | 3510 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 36 | 823 | 466 | 156 | 1445 | 2253 | 1824 | 4077 | 5522 |
| 37 | 846 | 479 | 161 | 1486 | 2274 | 1841 | 4115 | 5601 |
| 38 | 869 | 492 | 166 | 1527 | 2295 | 1858 | 4153 | 5680 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 45 | 1030 | 583 | 201 | 1814 | 2820 | 2283 | 5103 | 6917 |
| 46 | 1053 | 596 | 206 | 1855 | 2841 | 2300 | 5141 | 6996 |
| 47 | 1076 | 609 | 211 | 1896 | 2862 | 2317 | 5179 | 7075 |

Maximum $\pi$ is determined by the maximum possible daily production. In an 8-hour day there are 8(60) or 480 minutes. Since a brand change loses 15 minutes and a grade change 10 minutes, for one brand change and three grade changes there are left 480 − 15 − 3(10) or 435 minutes. The canning machine fills about 400 cans per minute and the filled cans are packed 24 to a case, therefore maximum daily production is (400)(435)/24 or 7250 cases. Using this value of P in equation (5) (but treating it again as an inequality) and the totals of I and S from Table I

$$\pi \geq \frac{\Sigma I + \Sigma P}{\Sigma S_A + 3\Sigma S_B} = \frac{58 + 7250}{41 + 114} = 47.15$$

Therefore the maximum integral $\pi$ is 47.

Any integral value of $\pi$ from 22 to 47 inclusive will now yield feasible solutions, each of which will satisfy all restrictions. Individual productions are calculated from equations (2) and (4) and are given in Table II.

While this methodology has been illustrated by application to production scheduling on a canning machine, many other applications should be apparent wherever one facility is used to produce more than one product, such as an inspection station, or a tester in a routine laboratory.

# From the Scrap Box

MASON E. WESCOTT, *Editor*

*University College, Rutgers University, New Brunswick, N. J.*

## Matrix Manipulator

***Editorial Note***

The material published herewith represents a Summary Technical Report prepared by the National Bureau of Standards, Department of Commerce, and distributed only to a selected list of editorial personnel. Since copies of this report are not available on an individual request basis, and since permission to publish has been granted, it is presented to *Industrial Quality Control* readers with the expectation that they will find it useful and interesting.

In computation involving matrices it is frequently necessary to interchange or rearrange rows or columns of a matrix. If the work is being done longhand or with a desk calculator, it is desirable to be able to perform the rearrangements without having to erase or rewrite numbers. A simple mechanical matrix manipulator which achieves this result has been designed by D. M. Mesner of the National Bureau of Standards. The possibility of designing a desk-size electronic instrument to perform the same operations is being considered.

Figure 1—Matrix manipulator devised by the National Bureau of Standards for quick rearrangement of the rows and columns of a matrix. Matrix cells are represented by plastic blocks, each with 2 horizontal holes, so that an entire row or column can be lifted out with a metal rod that is passed through the holes. Here two 8 × 8 incidence matrices, representing 2 networks are being compared; the black-topped blocks stand for 1's and the white blocks for 0's.

The matrix manipulator was devised for use in the Bureau's Statistical Engineering Laboratory for calculations with incidence matrices, i.e., matrices whose elements are all 0's or 1's. Matrices of this kind arise in many branches of science and pure mathematics, as well as in statistical analysis. The solution of systems of linear equations, perhaps the best known application of matrices, should also be facilitated by the manipulator.

The device consists of a set of small plastic blocks which can be arranged in a rectangular array to serve as cells of a matrix. The upper faces are sanded to provide writing surfaces for pencil or pen. The blocks are drilled with 2 horizontal holes each through which a metal rod can be passed, so that an entire row or column can be lifted out and replaced where desired.

If arithmetical operations result in new numbers in the matrix, the old numbers can be erased and the new ones put in their place about as easily as on paper. The blocks could also be replaced by others containing the new numbers. When working with incidence matrices, where only 0's and 1's occur, the matrix pattern can be more easily distinguished if the 1's are represented by blocks with a black top while the 0's are left white (see Fig. 1).

### *Comparing Networks*

A good illustration of a problem which can be solved by rearranging rows and columns of a matrix is that of determining whether or not 2 networks have the same structure. An example is shown in Fig. 2, which gives the diagrams of 2 networks each containing 8 boxes connected by lines. If the lines are interpreted as the appropriate form of connection or communication, then such networks might represent the connections in an electrical circuit, the flow of information between components in a computer, the channels of communication between departments of an organization, or the structural formula of a molecule, to mention a few of the possibilities. Whatever the interpretation of the diagram, any network can be represented in concise mathematical form by an incidence matrix with rows and columns labeled to correspond with the boxes. In such a matrix,

**TABLE I—Incidence Matrices**

| | Network I | | | | | | | | | Network II | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | A | B | C | D | E | F | G | H |
| 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | A | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| 2 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | B | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| 3 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | C | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 4 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | D | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 5 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | E | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 6 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | F | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 7 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | G | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| 8 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | H | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 |

the entry in position $x$ of row $y$ is set equal to 1 if boxes $x$ and $y$ are directly connected, or it is set equal to 0 if the same boxes are not so connected. The incidence matrices for networks I and II of Fig. 2 are given in Table I.

Suppose it is desired to know whether the 2 networks are as different as they appear, or whether they really have the same structure and differ only in the way the diagrams have been arranged on the paper. Put in another way, the problem is to find whether the boxes of network II can be relabeled with the numbers 1 to 8 in such a way that the pairs of boxes directly connected by lines in network II have exactly the same numbers as the connected pairs in network I—and vice versa.

However, renumbering the boxes of a network in a different order has exactly the same effect as rarranging the rows and columns of the incidence matrix in the corresponding order. Thus the networks are identical if we can find a rearrangement (permutation) of the

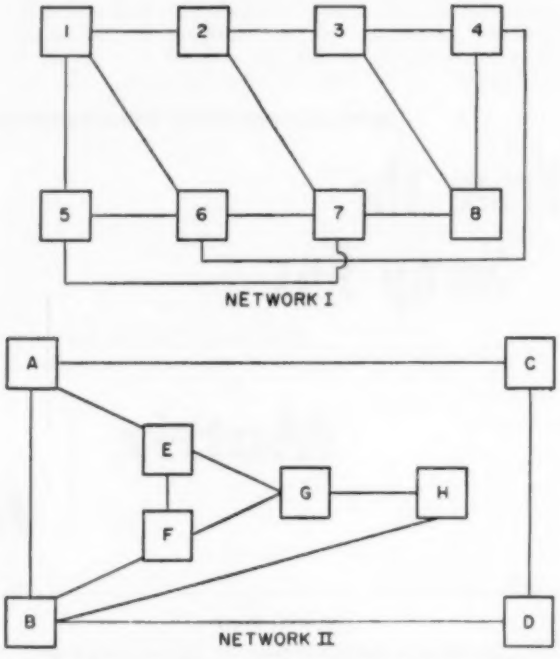


Figure 2—Schematic diagrams of 2 networks whose comparison is facilitated by use of the matrix manipulator (devised by the National Bureau of Standards). The networks might be interpreted, for example, as showing the flow of information between components of a computer. Each network can be represented by an incidence matrix (given in Table I), and if the matrices can be brought to a common form by rearranging the rows and columns (subject to certain simple conditions) the circuits are identical in structure even though appearing very different. Thus, it is found that the two networks illustrated have the same structure.

rows and columns of the second matrix which will give it exactly the same pattern of 1's and 0's as the first matrix.

The matrix manipulator makes it easy to try different arrangements. In working with an 8 × 8 matrix, an extra row and an extra column are added for carrying the numbers or letters that index the rows and the columns; the index row and column furnish a record of the rearrangement that has been carried out and provide a check that the same rearrangement has been used for rows as for columns.

In practice, it is convenient to set up both matrices on blocks and try to rearrange each of them into a common form. In the example of networks I and II, it is helpful to begin by placing the 2 rows that contain four 1's in leading position, then doing the same for the columns. A few trials are sufficient to find rearrangements that make the matrices identical, showing that the 2 networks do indeed have the same structure. When the matrix for network I is left unchanged, the rearrangement found for network II and its incidence matrix is: C A E G D H B F.

# Biometrics in Texas

HARRY M. SARASON

It seems that the football team at Washafornia State University decided last spring that they had a chance to play in the next Rose Bowl game. So, purely as a voluntary matter of their own accord the whole football squad decided to spend their vacation down on the ranch of their coach's mother near Amarillo, Texas where it was hot and dry and they could keep in good condition and practice some football plays. The coach, naturally, was going to spend his vacation on his mother's ranch too, but he wouldn't tell the boys what to do about football practice. Of course not, that just wouldn't be fair. It also happened that a very erudite and learned professor was also going along for his vacation, and thus, by pure coincidence, the squad would be able to keep in good mental condition as well as good physical condition for the big football season next fall.

As soon as the professor got off the ranch wagon at the ranch of the coach's mother he noticed that it was a dairy ranch, and he told the boys, "I am going to show you all how to increase the yield of milk on this ranch. I will do it by pure reasoning. Wait and see."

Sure enough, about a week later the professor came up with his idea. "Maw," he said, "You have 200 cows on this ranch. Do you mind if I divide them up into two equal herds and put them into different fields?"

"Why, no," said Maw, "That wont bother any."

"Well," said the professor, "And will it be OK if I put ice in the drinking water of half the cows?"

"Why, no," said Maw, "That wont bother any."

So the professor divided the herd up scientifically: the top producer with 6.00 gallons per day in herd A; the next two cows with 5.90 per day and with 5.98 gallons per day in herd B; then the next two cows in herd A, and so on until he had the herd divided into two equal herds of 100 cows each with average production of 4.00 gallons per cow per day in each herd. Two weeks later he made his report to the football squad.

"Well, boys," said the professor, "I did it. I divided the herd up scientifically into two herds of 100 cows each with average production of 4 gallons per day per cow and a standard deviation of one quart in each herd. Then I put ice in the drinking water of herd B, and the production immediately went up from 4 gallons to 5 gallons per day per cow in herd B. That's a 25 percent increase, and four times the standard deviation. What do you say to that?"

The third string quarterback was naturally eager to get in the picture and was very enthusiastic. "You did it professor," he practically shouted, " a 25 percent increase! Four times the standard deviation! Pure brain power. I gotta hand it to you professor."

The second string quarterback was a little smarter. "You gotta figure the cost, professor," was what the second string quarterback said. "Hauling ice may be fun for you, but it costs money on a commercial basis. Also ice costs money. And hauling another one or two hundred gallons of milk to market costs money. And where are we going to sell that much milk? For all I know, another hundred gallons or so may depress the price of milk."

"Excellent observations," said the professor. "Excellent observations. If necessary, however, we can make cheese and yogurt and butter out of the extra milk, and ship them to Switzerland or to Wisconsin. Any more comments?"


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The first string quarterback was really smart. "Professor," he said, "The first thing you taught us about the science of statistics was that the statistician should never rely on figures alone but should always discuss the whole matter with someone who was an expert in the facts and business underlying the figures."

The professor smiled a deprecatory smile. "Four times the standard deviation," he said, "a 25 percent increase! Oh, well, it won't cost anything to discuss this with the business expert. We will ask Maw about it."

Maw was passing by just then, so the professor put it up to her. "Maw," he said, "we put ice in the drinking water of half your herd, and their milk production went up from 4 gallons per cow per day to 5 gallons per cow per day. That is four times the standard. . . . Oh, well, you wouldn't know about that. What do you think?"

"Well," said Maw, "Let me get this straight. You put ice in the drinking water of half the herd, and their milk production went up from 4 gallons per cow per day to 5 gallons? Well, I think . . . . . ."

OK buddy, or sister, what did Maw think??????

*(Editorial Note—"Maw's" reply may be found on page 29.)*

# What's New?

ROY A. WYLIE, *Editor*

*When inquiring about "What's New?" items, please mention INDUSTRIAL QUALITY CONTROL*

Comparator Chart-Gages of professional quality can now be produced in any shop using a new material just introduced by **Optical Gaging Products, Inc.**, Rochester, N. Y. The material, known as "Fast-Line," is a specially coated plastic 0.050 inches thick. Chart-Gages are prepared on Fast-Line by scribing the desired layout, using elementary layout tools or scribing equipment. The scribed lines are then brushed over with a special dye-like fluid. After dipping in a wash to remove excess fluid and the scribe coating, the chart is wiped dry with a cloth or sponge and is ready for use. The "processing" time takes less than three minutes for an average chart—requires no technical skills, or special equipment. The finished Fast-Line Chart-Gage has sharp black (or colored) lines impregnated directly into the plastic. Chart-Gages are thus extremely resistant to wear and abrasion under shop conditions. Fast-Line material has excellent stability with respect to temperature and humidity changes, and is rated next to glass as a desirable chart layout material. Fast-Line Chart-Gage material comes with either clear or matte surface in sizes to fit all makes of optical projectors. It is distributed through Optical Gaging Products representatives and offices in the United States and Canada.

★ ★ ★

**Gaertner Scientific Corp.**, 1201 Wrightwood Avenue, Chicago 14, Ill., has introduced a new Viscometer for accurately measuring and recording the consistency of starch pastes. Designated the "Corn Industries Viscometer," it has been adopted as the standard testing instrument for the starch industry by the Corn Industries Research Foundation. The Gaertner Viscometer is used as a quality control and research instrument in both the dry and wet milling industries. In the brewing, pulp and paper, and confectionery industries, the new instrument is used as an inspection and control device for in-coming shipments of ingredients, as well as in the research laboratories. Other applications include textiles, leather tanning, food and chemical processing. The Gaertner Viscometer is designed to identify the physical properties of starches by continuous determination of apparent viscosity or consistency of starch pastes. Quality control tests can be completed at a rate of about 3 an hour and results can be determined to a repeating accuracy of plus or minus percent. The instrument consists of a stainless steel beaker immersed in a temperature-controlled water bath. A propeller, driven through a gear system, stirs the paste placed in the beaker. As the water temperature is raised, the viscosity of the paste varies and the changes cause the propeller to turn slower or faster. The differential torque is transmitted to a dynamometer and is registered as a pen trace on a continuously moving paper graph recorder. The new Viscometer is of an improved design that incorporates sturdier components for longer life and trouble-free operation. These include heavier gearing, and more powerful motor and heater. Other improvements include compact design, reduced height, and simplified operation and adjustment of gears, agitator, recording pen and leveling screws. A Gelometer attachment is available for use with the Viscometer. This gel tester uses the embedded disk method of measuring rigidity and breaking strength of gels.

★ ★ ★

New accessories for *DiaTest* High Precision Small Bore Gages that simplify many intricate measuring problems are available from **Foster Supplies Co.**, 6122 Milwaukee Ave., Chicago 30, Ill. The first accessory is a right angle attachment for gaging bores without removing the work-piece from under the bore spindle. The dial indicator can always be adjusted to face the operator. With use of extension rods the distance between work-piece and dial indicator can be increased to 30 inches without loss of accuracy. The second accessory is a Depth Adjuster used to gage a diameter at any desired depth. All parts and accessories are interchangeable and available separately.

★ ★ ★

An automatic bulk diode handler capable of sorting up to 3000 diodes per hour into as many as 16 classifications is now being marketed by **Electronic Control Systems Division of Stromberg-Carlson**, 2231 So. Barrington Ave., Los Angeles 64, Calif. The new E.C.S. sorting machine adapts to new or existing test equipment and readily accommodates a four parameter forward-back resistance test sequence without rehandling. Designed for use by diode

manufacturers and large scale diode purchasers, the new E.C.S. ASTRA-MATIC Model 276 Diode Handler is rated at 20,000 diodes per 8 hour shift for normal quality product. The equipment is designed to perform 10 million operations without major overhaul (approximately 2 years of continuous service). Operation is fully automatic. Diodes are transported automatically from hopper to bins, and bin contents are displayed on counters. The handling machine requires only refilling of hopper and removal of filled bins. One operator can supervise a bank of handlers. Maximum component body size handled by the Model 276 is 0.265 inches long by 0.105 inches in diameter with 1⅛ inch lead length, or a maximum overall length of 2½ inches. However, the equipment can be modified to handle axial lead components with other body sizes including diodes, resistors and capacitors. The new unit measures 5⅔ feet high by 23 inches wide by 24 inches deep. Power requirements are 115 VAC, 2 amps.

★ ★ ★

The "Multi-Mike," an instrument which measures both internal and external metal cuts and grooves and accurately determines groove locations, is announced by **Consolidated Aircraft Products,** El Segundo, Calif. The new multipurpose micrometer is fabricated of tool steel with a satin chrome protective finish. Only 8⅞ inches in length, it carries a standard type micrometer head. Two discs, each 0.574 of an inch in diameter and 0.025 of an inch in thickness, ground and lapped to fine gauge tolerances, form the "jaws" or measuring surfaces of the Multi-Mike. Other sizes can be provided for special applications. Measuring capability ranges from 0.050 to 1.050 inches and in measurement of "lands" or widths between grooves, from zero to 1.000 inches. Uses of the Multi-Mike include measurement of the width of "0" ring and retaining ring grooves, keyways, cylinder grooves and lands between grooves. Measurement of grooves can be accomplished in holes as small as 0.550 inches in diameter. It also can be used to measure groove distances from an external reference surface to a probe depth of 5.600 inches and can be adapted for use as a "snap-gauge" in the inspection of internal and external grooves during high production runs.

★ ★ ★

A complete line of Halogen Leak Detectors has been announced by **General Electric, Instrument Department,** West Lynn, Mass. Featuring four detector heads for use with one standard control unit, the series replaces the long-established Type H-1 model. Designated Types H-2, H-3, H-4 and H-5, the line is adaptable to a wide range of applications in almost every area of industry. Each of the new models is so sensitive it can locate leaks as small as $10^{-6}$ cubic centimeters per second—leakage of less than one ounce of escaped gas every 100 years. The new line locates leaks in any closed system or component — under pressure or vacuum — using any halogen compound tracer gas. The gas can be introduced as a tracer into practically any system that does not already contain a halogen gas. Tracer gases such as Freon, Genetron and Isotron are readily available. The standard control unit is portable and self-contained with a multi-range indicator. A loud speaker registers an audible alarm when the indicator exceeds a preset value as selected by means of a "cut-in" dial. Through an automatic balance circuit the detector responds only to increases in the amount of tracer gas present. This makes it possible to detect leaks rapidly and continuously without waiting for the instrument to clear itself. It also makes it possible to locate a leak when the entire atmosphere contains some tracer gas. The H-2 and the H-5 types are designed for manual leak-checking of closed systems and devices containing a tracer gas under pressure. The H-3 model has a stationary detector for automatic, high speed leak checking of parts moving past the detector on a conveyor. An auxiliary relay is available that can be used to initiate control that will reject "leakers". The H-4 is designed for detecting leaks in vacuum systems and suitable for many applications which formerly required use of the more expensive mass spectrometer leak detector.

★ ★ ★

A packaged portable unit for calibrating liquid flowmeters is now available from **Fischer & Porter Co.,** 694 Jacksonville Road, Hatboro, Pa. The comparison type calibration stand uses turbine flowmeters as the calibrating standard. Water, hydrocarbons and/or oils are used as the calibrating medium and accuracy of 0.5 percent of instantaneous flow rate is achieved. Range is from 0.5 to 150 gallons per minute. Variable area, turbine, positive displacement and orifice meters may be accurately calibrated and the basic design is flex-


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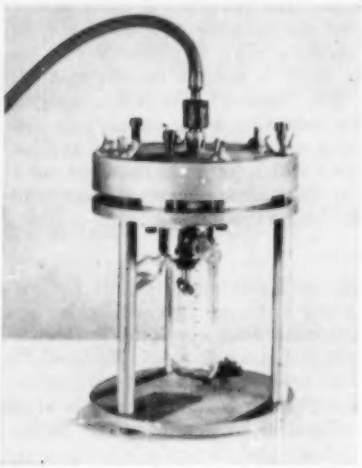


**Custom Scientific Instruments, Inc.,** Kearny, N. J. now offers the "Dow Gas Transmission Cell" to perform tests as specified in ASTM D-1434-56T "Tentative Method of Test for Gas Transmission Rate of Plastic Sheeting." This unit was developed by the Plastic Technical Service of the Dow Chemical Company. The redesigned cell will have the following advantages to aid the laboratory technician; the cell is calibrated for immediate use, all parts are removable for cleaning and replacement, and adapters are furnished for fast and slow gas transmission rates.

★ ★ ★

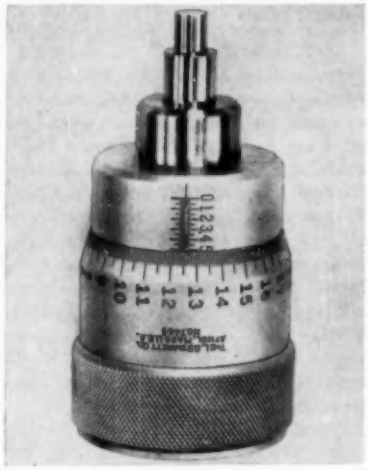
**Boice Gages, Inc.,** Hyde Park, N. Y. has announced the release of the smallest dial indicating bore gage. This gage is capable of checking bores down to 0.032 inches. By the use of interchangeable gaging heads, it is possible to check any bore within the range of 0.032 to 0.064 inches.

★ ★ ★

**Optical Gaging Products, Inc.** of Rochester, N. Y., has introduced the WP-100, the world's largest optical projector with transparent screen. This projector has a screen 60 inches wide and 40 inches high, making possible inspection of parts covering a field of 6 inches at a magnification of 10×. This field is twice the size that can be viewed on optical projectors currently on the American market. The new projector is primarily designed for the inspection of contours such as templates, gears, cam forms, screw threads, etc., and for the visual finishing of profile gages while actually imaged on the screen. However, virtually any optical projector inspection can be made with suitable auxiliary equipment. The projector was developed in England by Optical Measuring Tools Ltd. and is widely used in that country.

★ ★ ★

The **L. S. Starrett Co.,** Athol, Mass., has announced the Starrett No. T465 Micrometer Head, designed for use in electronic equipment requiring ultra-fine adjustment, for machine tools, fixtures, special gages, etc., where micrometer accuracy in settings and adjustment is required. The new micrometer head reads directly in ten-thousandths of an inch and has a 1-inch range. An important feature is a new constant-pressure nut which makes possible a wide range of tension adjustment from light to heavy to suit requirements. The thimble is 2⅛ inches diameter with widely spaced direct-reading "tenth" graduations permitting easy adjustment and reading. Other features are: quick reading graduations with every thousandth numbered, no-glare satin chrome



finish on thimble and sleeve, one piece hardened spindle with threads ground from the solid and stabilized, mirror-lapped finish on end of spindle. Micrometer heads built to individual requirements are also available on special order.

★ ★ ★

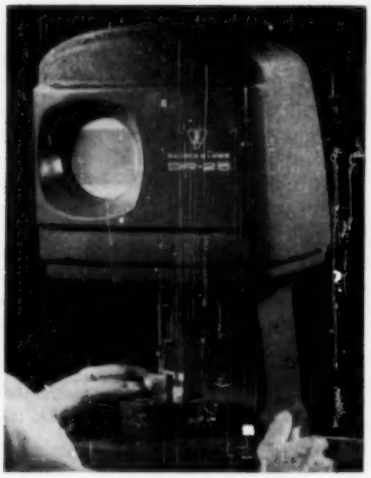
A new direct reading optical gage with high precision has been developed by the Bausch & Lomb Optical Co., Rochester 2, N. Y. This all purpose inspection and quality control measurement measures depth, thickness, height, and diameter with a range from 0 to 3 inches, with no masters or set gages needed. Measurements are read directly on an illuminated, magnified scale graduated in clearly defined least-reading intervals of 0.0001 inches, with an accuracy of 0.000025 inches. The scale

# *Resolution*

***Resolution by the Board of Directors of the American Society for Quality Control Unanimously Passed at Their Meeting May 27, 1958***

*WHEREAS the 1958 Annual Convention of the American Society for Quality Control has added another milestone to the Society progress, contributed materially to the further advancement of the science of quality control, promoted the good fellowship and cooperation of the members and has generally been one of the finest meetings held by the Society, be it resolved that the Society express its sincere gratitude to Warren Grosjean, Chairman for the Boston Host Section of the American Society for Quality Control and to his many capable committee chairmen and to all the members of the Boston Section who added so very much to this meeting.*

*WHEREAS the members of the Society heartily commend Wade R. Weaver and the General Convention Committee for their fine work in arranging a most interesting and educational program and exhibit for the 1958 Annual Convention and that the officers and Board of Directors of the Society extend a sincere note of thanks to all who took such an active part in this wonderful meeting.*



is made from a master scale ruled on the world-famous Bausch & Lomb Grating Ruling Engine, the ultra-precision instrument that is used to cut as many as 6,000 uniform grooves per inch on special optical surfaces. Accuracy of the scale of every DR-25 Optical Gage is carefully controlled. Although the extra-large work table makes it easy to adapt special fixtures, most parts need merely be laid on the anvil (flatness accurate to 0.000005 inches) for measurements to be made. A turn of the control knob lowers the spindle until it touches the part. The spindle stops automatically on contact and the accurate measurement is instantly readable on the scale. Priced at $695, the B&L DR-25 Optical Gage is distributed in the United States through **DoALL Company**, Des Plaines, Ill.

★ ★ ★

Cohesion Tester Model CS-83 developed by West Point Manufacturing Co. has been made available by **Custom Scientific Instruments, Inc.**, 541 Devon Street, Kearny, N. J. This unit was designed for dynamic measurement of forces involved in drafting strands of textile fibers such as sliver and roving. Such information is useful in determining the proper twist, evaluating fiber finishes and in studying the relationship of these and many other fiber characteristics to yarn quality. The apparatus provides a stationary set of drafting rolls mounted on a beam with a fixed speed of 25 rpm. The second set of drafting rolls are movable with respect to the first and have variable speeds obtained by change gears. The speeds of the second set are 24, 14, 9 and 6 rpm. The minimum separation between the two sets of rolls 1⅛ inches and the maximum separation is 8 inches. Both sets of rolls are gear driven by means of small synchronous motors. A transducer is mounted on the stationary rolls for measuring the drafting forces. This transducer translates the drafting forces and their fluctuations into electrical energy which in turn is measured and recorded continuously. Both drive rolls are fluted to avoid fiber slippage during drafting. The pressure rolls are rubber covered and pressure is applied through the bearings by means of screws at each end of the pressure roll shaft. The tester may be calibrated so that the drafting forces in grams can be read directly from the recorder chart. This is accomplished by separating the movable sets of rolls so that a piece of thread may pass between them and through the guide. With the thread held by the stationary set of drafting rolls a known weight may be hung on the thread to calibrate the deflection of the recorder in grams. The tester may be utilized in the study of inter-fiber friction forces encountered in drafting in connection with fiber lubrication studies and in analysis of mill problems involving unsatisfactory roving and yarn uniformity.

★ ★ ★

A new precision auto-collimator of Leitz-Wetzler (West German) make is announced by **Opto-Metric Tools, Inc.** of 137 Varick Street, New York 13, N. Y. The Leitz instrument departs from the traditional telescope design to increase its sturdiness, handiness and portability. The result is a compact optical tool, completely self-contained and independent of any mounting fixture. The ocular is rotatable against stops over an exact 90 degrees quadrant for measurements in two planes. Another innovation is a purely optical micrometer in which minutes and fractions of seconds are read within the one eyepiece. It also provides independent zeroing for the initial setting.

★ ★ ★

**Steel City Testing Machines, Inc.**, 8817 Lyndon Avenue, Detroit 38, Mich., announces their appointment as exclusive U. S. Distributors for the Penetrascope Portable Hardness Tester. The Penetrascope, which performs a Diamond Pyramid Hardness Test, is manufactured in England. The design, procedure of using the tester, and results obtained all conform to the American Society for Testing Materials Standard E 92-57. The Penetrascope weighs approximately 18 lbs. and is easily transported. It has consistent accuracy even when testing in normally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inaccessable places. The unit is especially useful in testing finished parts because the method leaves only a minute indentation on the surface. It can be used for testing a wide range of materials from thin metal strips to large mill rolls or cylinders. Tests are made with ease on profiles, recessed surfaces and gear teeth. All models are finished in a durable polychrome and are equipped with a mahogany carrying case for easy transportation. Interchangeable clamps are also available including the standard U clamps of various sizes, a chain clamp and the Electro-Magnetic clamp. Complete testers and service parts are available from Detroit stock for prompt delivery.

★ ★ ★

A new high voltage tester, Model 4505 HYPOT, for testing breakdown of all insulating liquids is announced by **Associated Research, Inc.**, 377 West Belmont Avenue, Chicago 18, Ill. The new HYPOT is designed to test insulation liquids such as transformer oil to meet ASTM and Federal Specifications. The features incorporated into this instrument include ample voltage range of 0 to 35 KV AC, 2 KVA capacity rating to meet ASTM and Federal Specifications, continuously variable test voltage control, and accurate test voltage metering directly across the electrodes. In addition to these features, Model 4505 is also available with built-in motor driven, automatic rate of rise control to increase test voltage at 3 KV/sec, as required by ASTM specs. Price of the unit is $785.00.

★ ★ ★

**Manufacturers Engineering & Equipment Corp.**, Hatboro, Pa. has announced a new Model II Glossmaster, a universal instrument for measuring ASTM gloss units of paints and similar material. The new instrument also permits goniophotometric information to be obtained. It is designed for ruggedness, low maintenance and stability of performance and can be operated by non-technical personnel. The Model II Glossmaster measures 20, 60, and 85 degrees ASTM gloss of materials. These gloss readings are taken from a 7½ inch meter that permits a precision of reading compatible with the instrument's overall performance. A single calibrated standard suffices for complete ranges of all angles. The instrument gives readings directly and instantaneously. Changing from one angle to another is accomplished by a switching arrangement. The instrument can be standardized for all angles in approximately 30 seconds, and frequency of restandardization need not be greater than once an hour. Sample viewing is obtained by placing the sample at the top of the instrument over the aperture port. Expansion of the instrument's scale for closer tolerances is an added feature of the Glossmaster. Relative gloss measurements with respect to a chosen standard are made by setting the gloss of the standard to 100 and using a 10 to 1 expansion scale. Measurements of the instrument are independent of line voltage over the range of 95 — 125 volts. Auxiliary information regarding the sharpness of the image of the source can be obtained from the instrument by making use of the receptor aperture substitution plate, which is readily injected into the optical system. This replaces the standard receptor aperture system with a system having apertures of half width.

★ ★ ★

Ferroflux, a low-cost, portable magnetic inspection device which effectively detects surface and sub-surface defects in ferro-magnetic material, is announced by **Ferro Machine & Tool Corp.**, 5514 W. Washington St., Indianapolis, Ind. The Ferroflux unit weighs only 23 pounds, and consists essentially of a "U" shaped 110 volt electro magnet which operates at 0.175 KVA on 110 volts. Because of its light weight and portability, Ferroflux can be effectively used at various stages in any fabricating operation, including inspection stations prior to expensive machine operations where it would be difficult or impractical to move such parts or assemblies to the inspection department for checking. The operation of Ferroflux is simple. The unit is placed on the part to be explored, so that both poles are in contact with the part. The current is turned on and the space immediately surrounding the pole assembly is painted with a solution holding minute particles of iron in suspension. These iron particles will concentrate wherever there is a surface or sub-surface break in the magnetic field. Such defects as cracks, laps, discontinuities, voids, slag inclusions, seams, grinding checks, hard spots, etc., are almost instantaneously disclosed—whether such defects are on the surface, or at considerable depth below the surface. Also indicated will be tool marks and cracks and stress in bending, forming, heat treating and welding. An area approximately four inches around the contacts, and between them, can be covered with the inspection solution and be visually inspected for particle build ups which indicate the presence of defects. The unit has been approved by the U. S. Air Force. The model P.K. Ferroflux unit is a complete inspection unit. In addition to the pole assembly and 10 feet of cord, it is equipped with two four-ounce bottles of fluid (one red, one black, for color contrast) and an application brush. The units are contained in a wood carrying case, 13 inches high, 10¾ inches wide, 6¾ inches deep. Accessories for pole assembly are available upon request. Additional Ferroflux Magnetic Solution can be ordered in 1 gallon quantities. The kit complete lists for $395.00, F.O.B. Indianapolis, Ind.

★ ★ ★

The Bureau of Aeronautics and several other government agencies are now providing manufacturers of equipment with current data on service performance of materials in usage as part of the Material Reliability Program. This information is often furnished to the manufacturer in the form of a punched card containing a microfilm insert. The microfilm may be read by the means of an optical viewer or enlargements made when necessary. Two new microfilm readers, one priced at $5.50 and the other at $59.50, are announced by the **Filmsort Co.** of Pearl River, N. Y. Both are designed to meet the demands for inexpensive, portable readers. The Filmsort Inspector "50", a portable mechanical unit, weighs five pounds; while the model "25" weighs approximately three ounces. The readers are made especially for the "D" or 35 milimeter size aperture. With this enlargement ratio, microfilms made at a 16 times reduction, can be viewed and checked with ease. The Inspector "50" has sufficient storage space for approximately 200 aperture cards. Its dimensions closed are 12 × 9 × 4 inches. The unit uses a 50 watt lamp and therefore needs no cooling system. The Inspector "25" is a magnifier with two lenses and a plastic mount for the insertion and registration of tab-sized aperture cards. Like the Inspector "50" the Inspector "25" covers the full "D" aperture. Its magnification is three times, which is adequate for documents filmed at a 16 times reduction. When folded, the dimensions of the Inspector "25" are 3⅞ × 2½ × ⅞ inches; when opened, the dimensions are 3⅞ × 2½ × 3 inches.

★ ★ ★

**The Englass Co., Inc.**, 57 Shady Way, Rochester 16, N. Y. has made available a new mechanics loupe with a

5× power lens. These loupes may be used in connection with height gages for easy reading of the numbers and graduations, with centermikes, micrometers, verniers, depth micrometers, sliderules, checking fixtures and other types of instruments. The loupe may be attached to any type of stand such as a Miti-Mite base to be used on various machines. Attachment is by a thumb screw and the focal length is fixed, while the lense may be swiveled through 360 degrees to accommodate any reading position. Price of the loupe is $4.50.

### *New Literature Available*

The Micrometrical Manufacturing Co., 345 South Main Street, Ann Arbor, Mich., has published catalog sheets illustrating the new type QC Amplimeter, the Type LK Tracer, and the Group III package. The new QC Amplimeter provides selective cutoff of 0.003, 0.010, and 0.030 inches roughness width cutoff when used with tracing speed of 0.1 inches per sec. or 0.010, 0.030, and 0.100 inches roughness width cutoff when used with tracing speed of 0.3 inches per second. The type LK Profilometer Tracer makes it possible to take surface roughness measurements on ⅛ inch ID's to a depth of 11/16 inches. It will measure more than 90 percent of all surfaces produced by industry which includes ID's, OD's, flats, tapers, narrow splines, and gear teeth. In addition it can be operated either by mototrace or by hand. The Profilometer Group III consists of the Type QC Amplimeter, The type V Mototrace, and Type LK Tracer with the Type BK Linkarm. This group provides a package that covers practically all standard surface roughness measurements.

Coleman Instrument Inc., 318 Madison St., Maywood, Ill., has published Bulletin B-246 detailing Coleman Nephelometers and the Coleman Nephelos System. Coleman Nephelometers are used to measure and control the clarity of beverages and other liquids, pharmaceuticals, industrial fluids, contaminants in water and bacterial growth rates. They can detect and measure Calcium, Magnesium, Sulfates, Chlorides or similar ions in trace amounts without filtering, drying or weighing. The Coleman Nephelos System is based on a set of permanent, numerically related Nephelos Standards and a photoelectric instrument which is strictly linear in its response to scattered light, even at intensities far below the visible level. Two instruments are available: The Model 7 Photo-Nephelometer for nephelometry only, and the Model 9 Nepho-Colorimeter which also incorporates an excellent filter-photometer system.

"Precision Measuring for Missile Production" is the title of a new, comprehensive brochure published by Federal Products Corp., 1144 Eddy Street, Providence 1, R. I. The brochure describes various types of Gages for measuring critical dimensions and dimensional relationships in a variety of parts for guided missiles.

A complete, new line of atomic instrument systems to measure and analyze radioisotopes in industrial, medical and biological applications is described in the Atomic Systems Catalog A-2 just published by Baird-Atomic, Inc., 33 University Road, Cambridge 38, Mass.

A Compilation of ASTM Standards on Paper and Paper Products and Shipping Containers is available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. The various ASTM standard and tentative specifications, test methods, and definitions of terms pertaining to paper and paper products, and shipping containers are grouped together in this publication. This edition supersedes the September 1955 issue. In the development of test methods, Committee D-6 and Committee D-10 each cooperated with the Technical Association of the Pulp and Paper Industry through the Joint ASTM-TAPPI Committees. Many of the methods in this publication have been reviewed by the joint committee. The designations of the corresponding TAPPI methods are given at the top of the title pages of the respective standards. There are 102 standards and related information in this compilation. Of this number, 6 are new, revised, or have had their designations recently changed. Price is $3.20 to members, $4.00 to non-members.

A new Application Data Sheet, Bulletin IR-4205 entitled *Infrared Analysis of Hydrocarbons in Inert Gases*, gives particulars concerning the use of the Beckman Model 21 Infrared Analyzer with oil-lubricated compressors used in compressing inert gases used in missile loading. Copies are available free of charge from Beckman Process Instruments Division, Fullerton, Calif.

### *SIXTH ANNUAL AIRCRAFT and MISSILES DIVISION CONFERENCE*

The planning and programming for the Sixth Annual Aircraft and Missiles Division Conference which is to be held in Dayton, Ohio on Nov. 17-18 is in the stage of final setting. The conference committee from the host Dayton Section has joined with the designated representatives of the Aircraft and Missiles Division and the Electronics Division liaison to build a program that is of interest to every member of the Society irrespective of affiliation or geographical location.

The content of the program truly reflects the change of the sponsoring group title to the Aircraft and Missiles Division. The speaker quality and the topical timeliness of the planned sessions have been enhanced through the proximity of Dayton to the Air Force procurement and research and development centers at Wright Patterson Field and the geographical position of Dayton as a cross roads of the machine tool, electronics, and growing missile industry.

The program format is reflected in the titles and formulations of a sample of a few sessions: "What Can Be Done to Improve Missile Quality and Reliability"—panel of outstanding experts from the defense department, the services, and industry; "Missile Quality and Reliability Problems as Seen from the Test Center; Quality Control in Repair, Modification and Overhaul"—reliability panel; Reliability as Related to Maintenance—suppliers panel; Quality Control in Nuclear Aircraft.

These and other topics establish that the time lapse from the first Sputnik has been sufficient to now permit a rational evaluation of a heretofore somewhat chaotic area. The gleanings of future requirements will show through the present stress for those perceptive enough to so discover. All Society members have a stake in this conference.

### *Answer to From the Scrap Box—Biometrics in Texas. . . . pages 23-24*

*(Here is what "Maw" had to say to the professor.)*

"Well," said Maw, "you put ice in the drinking water of half my herd, and their milk production went up from 4 gallons per cow per day to five gallons per cow per day? Well, I think that is an awful roundabout way to water milk!"

# *Dallas-Fort Worth Section Honors J. Y. McClure With "Professional Life" Night*

The Dallas-Fort Worth Section of the American Society for Quality Control held its sixth annual dinner meeting Thursday, June 12, in the fashionable Western Hills Inn, located midway between Dallas and Fort Worth, Texas. There were 210 members and guests present.

After installation of officers by Dr. A. W. Wortham, 1957-58 section chairman, Mr. J. Y. McClure, Vice President of ASQC and Quality Control Manager for Convair-Fort Worth, introduced Convair's Fort Worth Division Manager, Mr. August C. Esenwein, who was reported to be the guest speaker.

Then, as powerful lights flooded the room, Mr. McClure was told to take the seat-of-honor; that this was his "Professional Life."

Visibly surprised, he watched as friends dating back to his early days of aviation paraded across the stage. Each unfolded a chapter in McClure's colorful career, which includes 18 years with Convair.

Among the visitors who helped make the surprise complete was A. W. "Tony" LeVier, famous flier and test pilot, who won the 1938 National Air Races at Cleveland in an airplane called "The Fire-Cracker". "Mac", as McClure is affectionately called by his many personal friends, was the mechanic who kept the airplane flying. LeVier is now Director of Flight for Lockheed Aircraft Corporation, Burbank, Calif.

Another on the program was C. C. Flagg, Chief of Inspection-Modernization, Convair-Fort Worth, one of Mac's closest friends and associates for more than 21 years. He and Mac first met in 1937 and became fast friends when they found they were both interested in building racing aircraft. Together, they designed and built one of the smallest racing planes ever to fly. They didn't win any medals with it, but it was a "hot" ship.

Then, there was George Covington, Manager of Master Planning and Assistant to the Division Manager at Convair-San Diego. He and Mac met in 1940, when Mac was a power plant inspector and he was an electrical inspector on the B-24 final assembly line at Convair-San Diego. Mac soon was promoted to the first inspection supervisor on this production program. According to Covington, accuracy was an obsession with Mac. A stickler for detail, he inspected by the book and went even further—he helped write the book!

S. E. Kelly, Chief of Air Force Quality Control at Convair-Fort Worth, first met Mac in 1945; soon after Kelly was transferred to the Fort Worth Division. Kelly's summary of his acquaintance with Mac was: "I have watched him grow in stature and maturity from an enthusiastic and highly competent local Chief Inspector to a nationally known figure in the field of quality control. A man who can do this and take so many people with his is certainly deserving of my respect."

No program of Mac's professional life would be complete without something from T. L. Hoffmann, former Chief of Air Force Quality Control at the Convair facility, now Deputy Chief, Quality Control Division, SAAMA, San Antonio, Texas. It was not long after Hoffmann's initial assignment at Convair, in 1945, that he met Mac. According to Hoffmann, the thing that impressed him most was Mac's ability to see both sides of an issue and to deal with it honestly and promptly. Also to his credit was the fact that: "Mac never came into our office with anything other than a completely business-like attitude. Whenever he approached us, we could be sure of two things: First, that it was strictly business and, second, that whatever he had to discuss had been competely thought out beforehand from both sides of the fence. My personal opinion is that if there were more J. Y. McClures around the country, our job would be a lot easier."

This same feeling was expressed by Lt. Col. L. J. Hutton, Air Force Representative at Convair-Fort Worth Division, and by T. E. Hoffman, Chief of Inspection-Production. Col. Hutton was first assigned to Convair in 1955. Mr. Hoffmann has been directly under Mac, and one of his closest associates for more than 12 years.

Swinging abruptly from Mac's professional life in the aircraft industry, the scene shifted to his extracurricular activities. First, of course, in Mac's life, outside of his devotion to the aircraft industry, is his association with the American Society for Quality Control. So, who would be more appropriate to be the first in this line of old acquaintances than Herbert B. Epstein? "Herb" is Chief of Process Control, Chance-Vought Aircraft, Inc., Dallas, Texas. Herb and Mac met in October, 1951 at the first organizational meeting of the Dallas-Fort Worth Section. When the section was formally organized, Mac was one of the four directors and Herb was the section secretary. Herb continued up the ladder in the

One of the many highlights of the program—L. S. Eichelberger, Executive Secretary of ASQC, congratulates "Mac" while L. L. Turner, acting as Master of Ceremonies, prepares for the grand entry of the next surprise guest.

local section to chairman in 1953-54. Mac was elected a National Director of ASQC in 1953 and served in that capacity until he became an Executive Director in 1956. In 1957 he was elected Treasurer and in June 1958 was elevated to the post of Vice-President.

There could be no better time than this for the appearance of L. S. Eichelberger—a long-standing friend of Mac in the profession. In fact, he was one of the men in the Midwest who was a strong and able supporter of the Dallas-Fort Worth Section in the days of its infancy. Les is now Assistant to the Director of Quality Control of the A. O. Smith Corporation in Milwaukee, Wisconsin, and is Executive Secretary of ASQC.

Les first got acquainted with Mac at a Midwest Conference Board Meeting of ASQC in Indianapolis in 1953. Mac, Jim Coburn, and Herb Epstein were there representing the Dallas-Fort Worth Section. Les recalled one incident in Mac's early association with ASQC which he used to illustrate the fact that Mac is direct and to the point in his approach to a problem. It seems that Mac was not too familiar with the protocol and conventional red-tape involved in officer elections in regard to the Midwest Conference Board. Imagine how it shocked the Midwest Group when Mac actively campaigned for the position of Executive Director. Mac was not elected that year, but his efforts caused the Midwesterners to recognize that here was a man who was really interested in taking on responsibility. Needless to say, they accommodated him.

Then there is Mac's association with AIA and the Aircraft and Missiles Division of ASQC. This was ably expounded by Paul Allen, Manager of Quality Control and Customer Service for Beech Aircraft Corporation in Wichita, Kans. Paul presently is chairman of the Aircraft and Missiles Division of ASQC. His first association with Mac was in 1952 when he needed some information on inspection personnel ratios to shop labor serviced, by type of operation. Mac agreed to exchange data on these ratios with Paul. This was the beginning of the National AIA Quality Control System Study which is made annually by Paul for the AIA Quality Control Committee.

Paul exposed some of the humorous side of Mac's life when he related how that during the 1954 Midwest Quality Control Conference in Dallas, Mac, realizing that "foreigners" would experience some difficulty crossing the Texas border to attend the convention, arranged for the issuance of temporary permits for non-Texans to enter the Lone Star State. According to Paul, he uses his permit every time he comes to Texas. He had it with him that night as proof.

Next to give support and recognition to Mac's extracurricular activities was Richard M. Oliver, Secretary of the Aircraft Industries Association Quality Control Committee and formerly, Rear Admiral, United States Navy. Admiral Oliver and Mac met during the annual meeting of the AIA Quality Control Committee in 1954 at Dallas, Texas. When asked if any incident has occurred in his acquaintance with Mac which particularly impressed him, he replied: "He continually surprises me. However, something occurred once which gave me further insight into his character. During one of my trips to Fort Worth, Mac took me to a dinner meeting of the YMCA. This group was conducting a campaign for funds for the YMCA Boys Club. I was quite surprised when Davie O'Brien, (Ex-TCU Football Great) the Meeting Chairman, called on Mac to give the invocation. I knew that Mac was an all around performer, but hadn't realized he could emit quite so effectively in this particular area. I might comment here that, although the good Lord has not seen fit to elevate quality managers to higher levels within their companies too frequently, I am sure if He ever does, He will remember J. Y. McClure."

Speaking of the YMCA brought out two more men who have played an important part in Mac's life—Amon G. Carter, Jr., prominent Fort Worth businessman, financier, and civic leader, and Paul Hayward, President, West Side YMCA. Said Carter: "Mac did such a fine job as Chairman of the Management Committee in 1955, that he was re-elected to that post in 1957."

In addition to his other activities, Mac is also Chief Mechanic for the West Side bus fleet (one old, dilapidated, worn-out bus). The West Side bus was purchased from the County after all possible transportation had been squeezed out of it—so they thought. But, they didn't know Mac. He has kept that old bus running safely for several years..

As if Mac didn't have enough to do, and having two growing boys of his own who like to play ball, he got interested in Little League Baseball. This is how he got acquainted with Joe Burns and Dr. Howard Buxton, both "leading lights" in the West Side Lions Club. Mac saw that there was no Little League Baseball on West Side; so, in 1952 he set out to become President of the West Side Lions Club. It is needless to say, he was elected President in 1953. One of his first acts was to "sell" the board on his idea, and in July 1953, West Side Little League Baseball became a reality.

Since every pleasant occasion must draw to a close, who would be more appropriate to close this one than Mr. August C. Esenwein, Vice-President and Division Manager, Convair-Fort Worth? Said Mr. Esenwein: "I should like to take this opportunity to express my personal thanks for the solid, outstanding, and thoroughly commendable job you have done, Mac, in managing all aspects of the quality control problem at Fort Worth during our association. I consider you second to none in your professional capabilities and work record with Convair, while you have served, first as Chief of Inspection and later as Manager of Quality Control."

After the program, a special "renewal-of-old-acquaintances" party was given for Mac, the participants on the program, and officers of the Dallas-Fort Worth Section.

*(The entire program was documented on 16mm sound film and will soon be available in limited quantity.)*


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# BOOK REVIEWS

## *W. D. Baten, Editor*

*26 University Drive, East Lansing, Mich.*

AN INTRODUCTION TO PROBABILITY THEORY AND ITS APPLICATIONS by William Feller, Volume 1, 2nd. Edition, John Wiley and Sons, New York, 1957, price $10.75. Reviewed by Dr. Charles Kraft, Statistics Dept., Michigan State University.

It has been the reviewer's opinion that the first edition of Feller's *An Introduction to Probability Theory and its Applications* is a model textbook. It is introductory only in that it can be read by a mature undergraduate with knowledge of calculus. The topics discussed in the book touch upon almost all of the problems that are the subject of probability theory and these topics are presented both with a mathematically, rigorous development and with application to concrete and meaningful examples. These examples are taken from almost all fields of academic and industrial endeavor and most of them give, in addition to an illustration of theoretical notions, a useful solution to a practical problem. Every statistician should have at least a reading acquaintance with this book.

The second edition has preserved all of the good features mentioned above and has even more examples and exercises. The significant change is the addition of two new chapters. The first of these on coin tossing and random walks presents some surprising features of purely random trials. For instance, it is shown that in 20 tosses of a perfect coin in a penny matching game, the probability is more than a third that the less fortunate player will never be in the lead. This fact is contrary to the intuitive feeling that the lead should more or less alternate between the two players, and it emphasizes that purely random phenomena often present features which tempt the observer to speciously attribute them to some assignable cause.

The second added chapter is devoted to compound distributions and branch processes. It presents a discussion of the theory of sums of a random number of random variables. Examples showing the applicability of this theory to problems of population growth, nuclear chain reactions, survival of mutant genes, and amount of damage in a lightning storm are given.

# section briefs

**BALTIMORE** . . . The executive committee met June 10 at the Johns Hopkins University and discussed plans for the 1958-59 program. Edwin M. Glocker of W. R. Grace & Co., our new chairman, presided.

Although the program being planned will incorporate advanced applications of statistical quality control technology, it was emphasized that the elemental aspects should not be overlooked. In line with this thinking, a special program was considered whereby instruction in SQC theory would be given prior to any monthly meeting. Instructions would be given by section members teaching in local educational institutions and others. It was agreed that this innovation may be of considerable help to those with inadequate statistical background.

Nine meetings are being scheduled with the new season being "kicked off" Sept. 16.

Past chairman W. A. MacCrehan agreed to investigate the possibility of having the 1960 Middle Atlantic Conference held in Baltimore.

**BINGHAMTON** . . . The section was the recipient of the Saddoris Award for Section Management in 1957. Charles Rubin, 1957-58 section chairman, received the Saddoris Award plaque, banner, and certificate at the Convention held in Boston.

In recognition of the achievement, Binghamton's Mayor, the Honorable John J. Burns, issued a proclamation declaring the week of June 16 as "Quality Control Week in Binghamton." Activities during quality control week included a window display in the Marine Midland Bank and a television interview of prominent quality control leaders in local industry. Those interviewed included: Charles Rubin, General Electric Co.; Joseph Fernbach, IBM; Jim Anderson, Ansco; and H. G. Thompson, General Electric Co. The interview was conducted by Ralph Carroll over WNBF-TV which has an audience of some 600,000 viewers.

**BINGHAMTON—A proclamation declaring the week of June 16th as "Quality Control Week in Binghamton" was presented to the section by the Mayor of Binghamton. Shown at the presentation are: (left to right) R. L. Fiaschetti, ASQC Executive Director; C. H. Rubin, 1957-58 section chairman; Mayor John J. Burns; J. A. Kirauch, 1957-58 vice chairman; and D. L. Moses, 1957-58 secretary.**

**BIRMINGHAM** . . . A meeting of section officers was held Friday, June 13. The adverse date did not hinder planning for an interesting and varied program for the coming year.

A two-day conference, a plant trip, and a joint meeting with the Huntsville section were some of the activities discussed. Edwin H. Phelps, the outgoing chairman, presided.

**CORNING-ELMIRA** . . . Approximately 40 members and guests enjoyed a fine evening of sports, dancing, and food at the annual outing held June 14.

**CUMBERLAND** . . . The section, in association with the Western Maryland section of ACS, sponsored an informal dance on June 20 at the Maplehurst Country Club in Frostburg. A buffet supper was served at intermission. Approximately 35 couples attended the affair.

**HAMILTON** . . . At an executive committee meeting held on June 18 in Fischer's Hotel, the various committee chairmen were appointed and a program for the new season drawn up. With special attention being directed to joint meetings with our neighboring sections, and initial plans being made for an all-day conference which will be held in October or November, our members may look forward to an interesting and informative series of meetings.

"Quality Control in Canada" was the title of the television program presented over Channel 11 on June 25. The program was sponsored by the Toronto section with the Hamilton section being represented by chairman Al Mitchell and Miss Marjorie Baskerville. The viewers in the Hamilton area were treated to a very fine "live" demonstration and explanation of just what "quality control" does in industry.

## SECTION CALENDAR (AUGUST 20-SEPTEMBER 31)

| SECTION | DATE | PLACE | TIME | SUBJECT | SPEAKER |
|---|---|---|---|---|---|
| Baltimore | Sept. 16 | Memorial Stadium | 8:00 pm | Discovery Sampling by Attributes | Ervin F. Taylor, The Martin Co. |
| Corning-Elmira | Sept. 9 | Elmira | 8:00 | Lighting for Inspection—How Much Do You Want Your Inspectors to See? | Willard Allthin |
| Hamilton | Sept. 19 | Canadian Westinghouse Auditorium, West End Plant | 8:00 | Training for QC | S. P. Zobel |
| Hartford | Sept. 2 | Club Alden | 7:00 | Executive Committee Meeting | ——— |
| Montreal | Oct. 25 | Ecole Polytechnique | 9:30 am | Second All-Day QC Forum | ——— |
| Pittsburgh | Sept. 23 | Penn-Sheraton Hotel | 8:00 pm | ——— | ——— |
| Rochester | Sept. 16 | C. of C. | 6:15 | ——— | ——— |
| | Sept. 23 | C. of C. | 6:15 | ——— | ——— |
| San Antonio | Sept. 9 | Hilton Hotel | 7:30 | Gage & Inspection—Problems and Solutions | Robert D. Brandon, Detroit Arsenal |
| San Francisco Bay Area | Sept. 19 | Stanford University | ——— | Fifth Annual Quality Control Conference | Charles T. Shewell, Humble Oil & Refining Co. |
| South Texas | Sept. 10 | Ben Milam Hotel, Houston | 7:15 | Your National Society and YOU | ——— |
| Toledo | Sept. 11 | Angelo's Restaurant | 6:30 | Machine Capabilities | Brent C. Jacob, Minneapolis-Moline Co. |
| Toronto | Sept. 20 | Pickering Golf Club | 11:00 am | Second Annual Golf Tournament | Arrangements—Murray Smith, Canada Iron Foundry |
| | Sept. 20 | University of Toronto | 8:00 pm | Process Control or Product Control | Frank McLaughlin, General Electric Co. |
| | Sept. 24 | Pilkington Glass Mfg. Co., Ltd. | 7:30 | Plant Visit | ——— |




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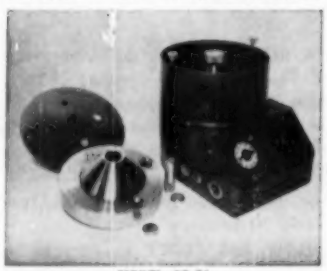

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It is with deepest regret that the Hamilton section announces the passing of its section chairman, Mr. Albert S. Mitchell, on Tuesday. July 22nd, following a severe heart attack.

Al, who was in his 45th year, had been a member of the section since its inception. He had been a member of the staff of The Steel Company of Canada since 1936.

Al will be greatly missed, both for his work and his sterling character.

**HARTFORD** . . . All executive committee meetings are to be held at 7:00 pm the first Tuesday of each month at the Club Alden. Members of the committee for the 1958-59 year are: chairman—Frank Hauman, Royal McBee Corp.; vice chairman—Herbert A. France, Jr., E. Ingraham Co.; secretary—Frank Zega, Torrington Mfg. Co.; treasurer—MacChesney Desmond, Hamilton Standard; arrangements— Charles Kropp, Hamilton Standard; membership—James Gleed, Pratt & Whitney Co., Inc.; education—Kenneth Martin, Royal McBee Corp.; technical society liaison—Albert E. Aubin, Underwood Corp.; publicity—Stanley Straska, Royal McBee Corp.; IQC correspondent—Frederick L. Jacobs, Heublein, Inc.

**KANSAS CITY** . . . The June meeting featured the announcement of complete committee assignments for the coming year. A business meeting was the order of the evening with members attending the National Convention furnishing a complete report of convention proceedings. An "opinion survey" was conducted to obtain members' preferences for time, place, and type of programs desirable.

**MID-HUDSON** . . . Thirty-one members were present for the annual social evening on June 3 at Germania Hall in Poughkeepsie. Entertainment was furnished by the King Tones, a barber shop quartet. In addition, a movie titled "Rooster Tails Flies" concerning outdoor motor boating was shown.

**MILWAUKEE** . . . A meeting of the executive committee was held on June 16 at the Hotel Stratford. Plans were made for the coming season a program which will include a variety of subjects from professionalism to operations research. Also planned are the annual Ladies Nite and National Officers Nite programs.

An educational series will be given again with the subjects yet to be determined. In conjunction with this series, the section is considering a 16-week course on precision measurement to be given in conjunction with ASTE.

Preliminary plans were also formulated for the 6th Industrial Clinic to be held in Milwaukee on Mar. 20, 1959. The theme of the clinic will be "Greater Quantity, Better Quality, Lower Costs."

**MINNESOTA** . . . The officers for 1958-59 are: Merm Olson, Telex Co., chairman; Richard Keefe, Remington Rand Univac, vice chairman; William Beck, Minneapolis Honeywell Regulator Co., secretary; Byron Brown, University of Minnesota, treasurer.

**MONTREAL** . . . The Second All-Day QC Forum will be held Oct. 25 at the Ecole Polytechnique beginning at 9:30 in the morning. The theme of the forum is "Solving Industrial Problems Through Better Quality Control." Dr. A. V. Feigenbaum will be guest speaker, with many other well-known speakers participating.

Additional information may be obtained by writing to A. F. Schmidt, Dept. 4853, Northern Electric Co., Inc., P.O. Box 6124, Montreal, Que.

**NEW HAVEN** . . . The first executive meeting of the new officers was held June 8 at the Chamber of Commerce. Tentative plans were formulated for the coming year.

The first meeting on Sept. 9 will be a picnic to be held at Echo Ridge Farms. There will be games and a chicken dinner with all the fixings including clams on the half shell, corn on the cob, beer, and clam chowder. At last year's picnic, a very enjoyable time was had by all and no one went away dissatisfied.

**OMAHA-LINCOLN** . . . The last meeting of the 1957-58 year was held at the Capitol Hotel in Lincoln June 13. Twenty members and guests heard Roy Borgstadt of the Omaha Western Electric plant speak on "Installation of the quality control program."

**PITTSBURGH** . . . Negotiations for a basic course in QC to be given in the evening adult education program have been undertaken with Dr. Earl A. Dimmick, superintendent of schools, Pittsburgh Board of Education, by Frank Caplan, section education committee chairman. The course would be open to the general public and cover inspection and statistical methods. It has been proposed that the lectures be given by different persons, in order to best utilize the various specialties of the members of the section. The course to be given in the fall semester would be under the general direction of C. F. Hoffmaster, director of vocational and industrial arts education. The proposed course is an outgrowth of the successful series of talks given at a senior high school as part of the automation and instrumentation program last year.

**RHODE ISLAND** . . . The organizational meeting for the 1958-59 year was held at the home of C. M. Antonio. The new officers were acquainted with their duties and responsibilities. Present at the meeting were C. M. Antonio, F. W. Killing, J. G. Kowalski, L. W. Balser, A. LaGreca, R. B. Fournier, F. Bliven, and R. Shaw Goldthwait.

The first regular meeting will be held in September at which time our speaker will be Richard Callahan from the Newport Naval Base.

The quality control course offered in cooperation with the University of Rhode Island will begin Sept. 24. It will consist of three courses—each ten weeks in duration.

After the close of the business meeting, Mrs. Antonio served very tasty sandwiches, cake, and coffee.

**ROCHESTER** . . . The first meeting of the 1958-59 season will take place at the Rochester Chamber of Commerce at 6:15 pm on Sept. 16. Speaker and subject information are not available at this time.

The first meeting of the gaging and measurement subgroup will take place at 6:15 pm on Sept. 23 at the Chamber of Commerce. The speaker will be Robert D. Brandon, chief, gage engineering unit, Detroit Arsenal. Mr. Brandon will discuss gaging and inspection problems and solutions in quality control. The lecture will be illustrated.

**SAN ANTONIO** . . . The 1958-59 program is already 80 percent complete and the loose ends of the program were the subject of discussion at a recent executive meeting of the newly elected officers. An exciting and informative program is well underway and includes nine scheduled prominent speakers, one of which is tentative, and a course in "Basic SQC" planned for the membership and their families. Our coming program is anticipated to be one of the most enjoyable and successful ever to be presented.

Sincere thanks from the section membership are extended to our outgoing officers for their untiring efforts in managing the section affairs during 1957-58.

**SAN FRANCISCO BAY AREA** . . . The Fifth Annual San Francisco Bay Area Quality Control Conference will be held Sept. 19 at Stanford University. The conference is jointly sponsored by the section and the Stanford Industrial Engineering Department. Grant Ireson, head of Stanford Industrial Engineering, is conference chairman.

**SOUTH TEXAS** . . . No regular meetings are scheduled during the summer months but committee activities continue.

A program advisory committee composed of E. S. Aldredge, R. C. Ellis, C. F. Lewis, L. G. McQuarrie, J. H. Moyer, and R. M. Shappee met recently with program chairman E. R. Hendrick and general chairman L. M. Buttery to complete the planning of the program for the 2nd Annual All-Day Conference to be held on Feb. 7, 1959.

Routine business was considered at the final executive committee meeting of the year with both the incoming and outgoing officers attending. It was announced that the section had been designated to sponsor the 3rd Annual Chemical Division Conference to be held in Houston in October, 1959. J. H. Moyer was appointed to serve as general chairman.

**TOLEDO** . . . The 1958-59 directors are: Jack B. Schneider, Toledo Stamping and Mfg. Co.; Margaret A. Tobin, Textileather Div., General Tire & Rubber Co.; and Fred J. Weber, National Carbon Co.

The first regularly scheduled meeting of the 1958-59 season will be held at Angelo's Restaurant on Thursday, Sept. 11,


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at 6:30 pm. Brent C. Jacobs, director of manufacturing at the Minneapolis-Moline Co., will speak on "Machine capabilities."

**TORONTO** . . . A very pleasant and informative plant tour was offered by the management of Christie's Bread, Ltd. to members and their ladies. All participants were deeply impressed by the cleanliness of the plant and the care taken to insure uniform and delicious products.

On June 25 the section, in cooperation with the other Canadian sections, organized a series of live television interviews over Channel 11 (Hamilton). Prominent members told the viewers about their quality control programs and how they solved them using statistical techniques. The show was designed for the average layman and drew very favorable comments.

The Second Annual Golf Tournament will be held on Sept. 20 at the Pickering Golf Club. Just as last year, the entire organization of this sporting event is in the hands of Murray Smith.

**TULSA** . . . Several Society members and guests met on Apr. 4 for the purpose of organizing a new section in the Tulsa area. With the sponsorship of the Michigan section and the help of their representative, A. A. Procassini of Argus Camera Division of Sylvania Electric Products Co., the meeting was a tremendous success. (Of the 31 persons in attendance, 29 became members.) The section was organized in a total of less than two weeks from the time that the Michigan section offered their assistance. Gail Phillips of the Michigan section was the man behind the guns in starting the Tulsa section. The charter request was approved at the Society's executive committee meeting held in Cincinnati, Ohio on Apr. 11 and Tulsa became the 105th section of the Society. The newly elected officers are: Robert J. Cottingim, chairman; Clyde W. Crenshaw, vice chairman; James A. Perry, secretary; Kenneth C. Jung, treasurer; Donald L. Hagerman, director; and Ralph A. Wood, Jr., director.

The first regular meeting of the section was held on May 19 in Bordens Cafeteria, Sheridan Village. Gail W. Phillips, of the Corporate Staff of Vickers, Inc. of Detroit, lectured on "Reduction and control of costs through quality control." This was a special treat since Mr. Phillips was so instrumental in the organization of the section. Although Mr. Phillips confessed to this being his first lecture attempt at a section meeting, those present felt that he did a very commendable job. Dr. John Hamblen, professor with Oklahoma State University, was appointed as a section director. There were 43 persons in attendance.

The June meeting was held at Bordens Cafeteria, Sheridan Village. Leonard Lueken, chief of the quality control section of the St. Louis Ordnance District, lectured on the Ordnance Manual #ORD-M-608-8 and the handbook used by the Ordnance inspection teams to evaluate a contractor's quality assurance program. An excellent sound and colored movie was shown of a typical examining team in action. Thirty-four persons attended the meeting.

The educational course planned for this fall has been announced. It will be held on the first, second, and fourth Monday night of the month. The third Monday night will be the regular meeting night. All meetings will be held in the Sky Room of Bordens Cafeteria, Sheridan Village.

A one-day forum will be held on Apr. 4, 1959 to commemorate the anniversary of our founders meetings. Three or four lectures will be offered during the day, with a banquet that night to complete the gala occasion.

**UNIVERSITY OF WESTERN ONTARIO** . . . An executive meeting was held June 19 in Kitchener to plan the program for the coming year. It was decided to hold eight meetings from September to April. These are to consist of two dinner meetings with prominent speakers, two panel meetings held in conjunction with the London Foremans Club and Canadian Industrial Management Association, two regular meetings with local speakers, a joint forum with the Hamilton section, and an informal meeting to close the year. In addition, two plant tours will be held.

The September meeting is not definitely settled as yet.

## SIGNIFICANT DIFFERENCES

. . . Binghamton—John Schneider and Don Moses have recently been promoted from associate engineers to staff engineers at the IBM Corp.

. . . Corning-Elmira—Robert L. Goldsmith received his M. S. degree in applied statistics from Villanova University. Bob is a statistician for the chemical and metallurgical division of Sylvania Electric Co., Inc. at Towanda, Md.

Thomas Hohn has left the section since his appointment as quality control supervisor of the Muskogee, Okla. plant of the Corning Glass Works.

. . . Cumberland—Retiring section chairman Robert E. Hunter has assumed the position of technical assistance to the plant manager at Celanese Venezolana in Valencia, Venezuela. He was previously an extrusion development engineer at Celanese Corporation's Amcelle plant.

Conrad Hohing, Jr., former director of the lubricants development department at Celanese Corporation's Amcelle plant, has accepted the position of quality control supervisor at the Onyx Oil and Chemical Company of Jersey City. His new duties are to direct all quality control functions at Onyx.

. . . Kansas City—Bendix Aviation Corporation announced the promotion of H. C. Heyde, formerly quality control manager, to the position of factory manager. C. L. Mann, formerly special assistant to the general manager, assumes the duties of quality control manager.

. . . Mid-Hudson—William M. Cranston, 1st vice chairman of the section, spoke on "Some applications of SQC in the graphic arts" at the Graphic Arts annual convention held recently in Los Angeles.

. . . Milwaukee—Edward Harry, formerly with General Electric Co., De Kalb, Ill., has joined the Bucyrus-Erie Co., South Milwaukee, as quality control engineer.

Edward Piotrowski, formerly with the inspection department of the Massey-Harris Co., has joined the Bucyrus-Erie quality control group as a trainee. Prior to this most recent assignment, he was a production supervisor and member of the industrial engineering department at B. E.

. . . Pittsburgh—Section president John Hromi, U. S. Steel Corp., attended the six weeks summer session at Oklahoma A & M.

William Horton, Westinghouse Electric Corp., has been invited to give a talk on experimental designs at the Rutgers Conference.

. . . Toledo—John D. Demiankow recently accepted a position at the Solid Fuel Division of Aero-Jet General, Sacramento, Calif. Prior to his appointment, John was chief statistician at the Textileather Division of General Tire & Rubber Co.

. . . Tulsa—We're sorry to hear that Dr. John Hamblen is leaving for the University of Kentucky, but our loss will be their gain.


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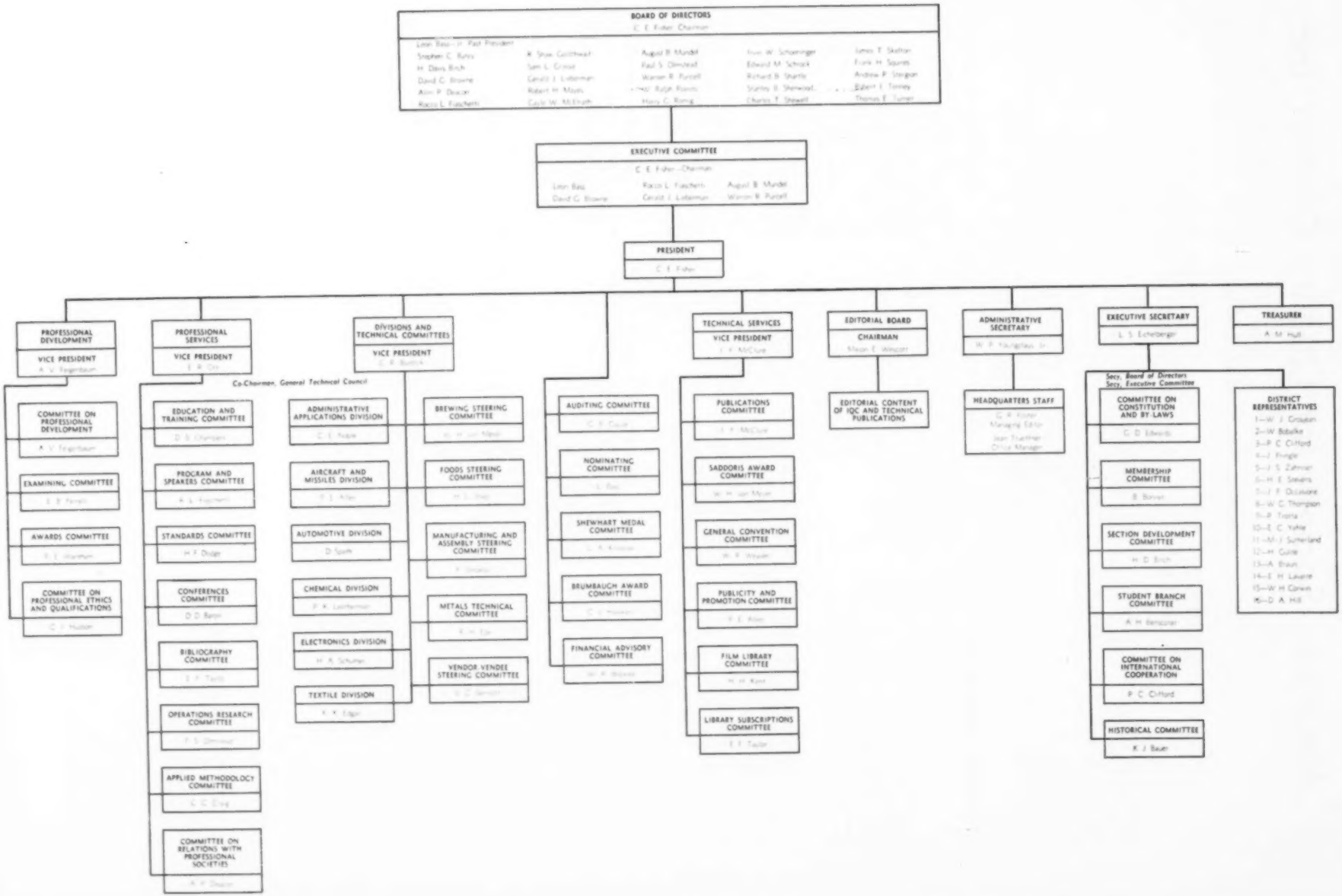
## Organization Chart for 1958-59



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. . . ***8-19***—Quality Control Short Course, Washington University, St. Louis, Mo., sponsored by Washington University with cooperation of St. Louis section of ASQC, contact Industrial Engineering Intensive Courses, University College, Washington Universtiy, St. Louis 5, Mo.

. . . ***15-19***—13th Annual Instrument-Automation Conference and Exhibit, Philadelphia Convention Hall, Philadelphia, Pa., sponsored by ISA, contact Fred J. Tavery, Exhibit Manager, Instrument-Automation Conference and Exhibit, 3443 So. Hill St., Los Angeles, Calif.

. . . ***22-24***—7th Annual Meeting of the Standards Engineers Society, "Standardization — A Must for the Space Age," Benjamin Franklin Hotel, Philadelphia, Pa., sponsored by SES, contact F. F. Van Atta, 1916 Race St., Philadelphia 3, Pa.

. . . ***23-26***—Iron and Steel Exposition and Convention, Cleveland Auditorium, Cleveland, Ohio, sponsored by Association of Iron and Steel Engineers, contact Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh 22, Pa.

### OCTOBER

. . . ***1***—Regional Technical Conference, "Plastics in Packaging," Hotel Statler-Hilton, Hartford, Conn., sponsored by Society of Plastics Engineers, advanced registration fee—$9.00 for SPE members and $10.00 for non-members, contact Registration Chairman, Lawrence W. Freeman, Plax Corp., Bloomfield, Conn.

. . . ***2-3—Second Annual Conference of the Chemical Division, Hotel Statler-Hilton, Buffalo, N. Y., sponsored by ASQC, contact V. B. Shelburne, Publicity Chairman, Chemical Division Conference, The Carborundum Co., P.O. Box 337, Niagara Falls, N. Y.***

. . . ***13-15***—International Systems Meeting, Penn-Sheraton Hotel, Pittsburgh, Pa., registration fee $100, contact 1958 ISM, Parlor 70, Penn-Sheraton Hotel, Pittsburgh, Pa.

### NOVEMBER

. . . ***10-14***—Third Annual Paperwork Simplification Conference, University of Dayton, Dayton, Ohio, contact University of Dayton, 300 College Park Ave., Dayton 9, Ohio.

. . . ***17-18—Sixth Annual Conference of the Aircraft and Missiles Division, Biltmore Hotel, Dayton, Ohio, sponsored by ASQC, contact R. B. Van Lehn, Vernay Laboratories, Yellow Springs, Ohio.***

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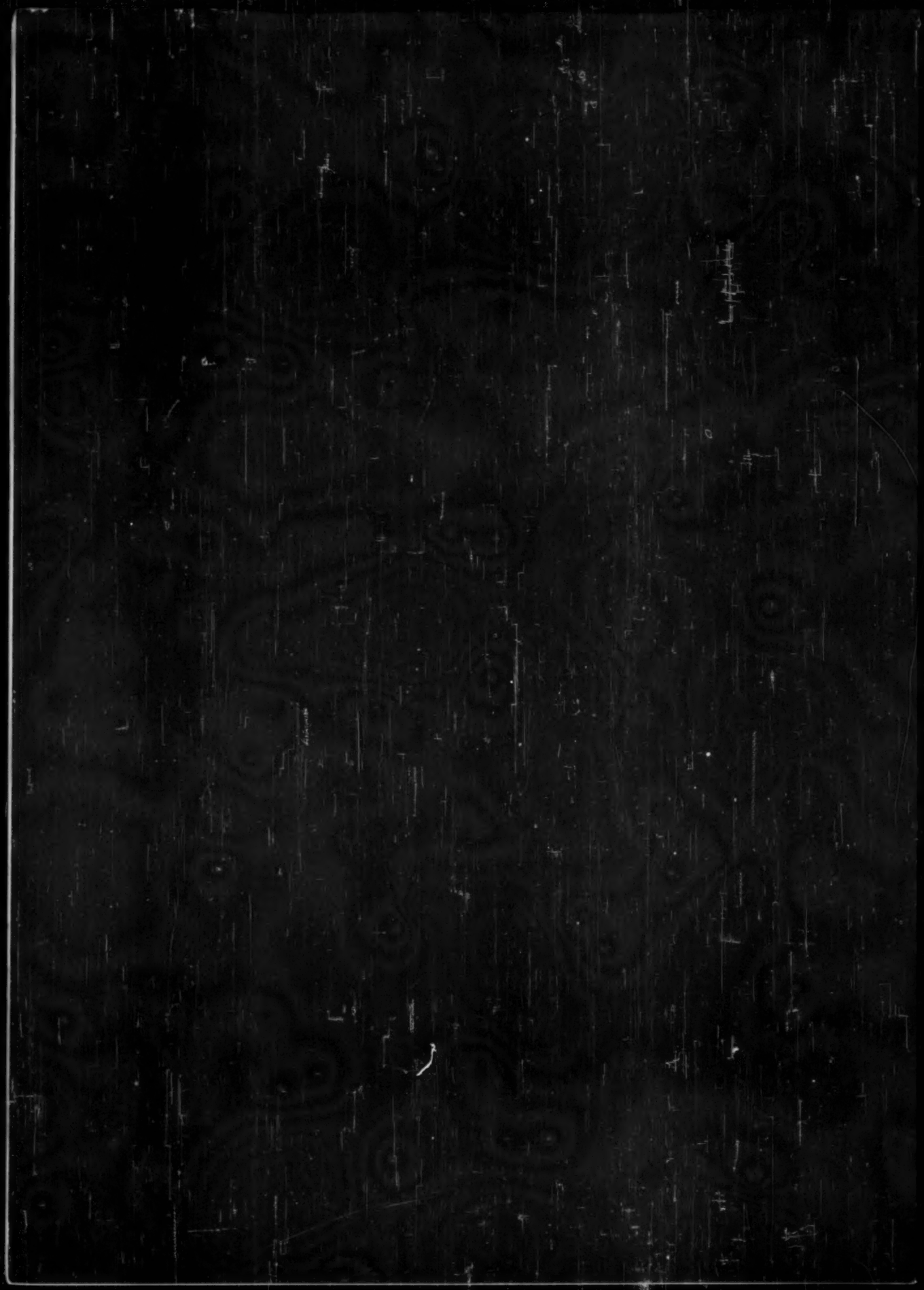
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